SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1918.

GENERAL PHYSICS.

325. *Machine for Differentiation.* **K. Hürthle.** (Zeits. Instrumentenk. 37. pp. 225–230, Dec., 1917.)—Describes, with the aid of several diagrams, a machine which will draw the differential of a given curve. Certain novel features are introduced in the design. The curve whose differential is required is caused to move with slow uniform speed underneath the apparatus by means of clockwork, and the curve is followed with the help of a reading microscope. This microscope has fine cross-wires, one of which is adjusted, by rotation of the microscope about its axis, so as to be tangential to the given curve. A steel ribbon attached to a cylinder carried by the microscope is used to operate the registering mechanism, for details of which the original paper should be consulted. A. W.

326. *Mechanical Differentiation.* **A. Elmendorf.** (Frank. Inst., J. 185. pp. 119–130, Jan., 1918.)—Describes in detail, with several diagrams, an instrument designed for obtaining the derivative of a given curve. In its earlier form it was similar in some respects to Erskine-Murray's differentiator [see Abs. 3151 (1904)], but the latest arrangement embodies the "integrating roller" device used in the Coradi integraph, so that integration to check the accuracy of the differentiation is now possible. A. W.

327. *Some New Instruments for Oceanographical Research.* **H. Pettersson.** (Monthly Weather Rev. 45. pp. 159–164, April, 1917.)—Describes: (1) A densimeter working on the float principle which records the depth at which water of a given density is found close in to the coast. (2) A densimeter of a different pattern which gives the mean density of the column of water between any two levels, adapted for eye readings only. (3) A simple direct method of reading the density of a given sample of water to a considerable degree of precision [see also Abs. 1 (1918)]. (4) A recording current meter. This is anchored at the position where it is desired to determine the current; it will run without attention for a fortnight.

It is suggested that the following programme of research would be likely to lead to very valuable new discoveries. (*a*) The existing network of meteorological stations should be extended over the oceans by means of an adequate number of steamers reporting by wireless. These telegrams should include observations of the temperature and salinity of the surface water. (*b*) A special survey of the most important cold and warm ocean currents and their regions of junction or conflict should be systematically maintained by cruisings of research steamers fully equipped for meteorological and hydrographical observations. (*c*) The internal movements, both horizontal and vertical, in the stratified water near the coasts should be followed by regular observations from a sufficient number of fixed stations and lightships along the coast line. J. S. Di.

328. *Influence of Air-resistance on Projectiles in Rotation.* **P. Appell.** (J. de Physique, 7. pp. 5–10, Jan.–Feb., 1917.)—Carrière has studied experimentally the aerial trajectories of light spherical balls of homogeneous material rotating about an axis perpendicular to the plane of the trajectory through the centre of gravity, and has described the varying form of the trajectory according to the sense and magnitude of the rotation. When the sphere does not rotate, the established theory is that the resistance of the air acts as a force applied at the centre of gravity and directed in a contrary sense to the velocity, its magnitude being a function of the velocity and increasing with it. In this case of no rotation, Carrière's experiments gave the classical trajectory. When, however, the sphere rotates about an axis perpendicular to the plane of the trajectory, the form of the latter may change in diverse ways, the cause of which should be sought more especially in air friction on the ball surface; this friction produces force elements, which, when referred to the centre of gravity, have a resultant depending on the sense and intensity of the rotation. According to Zahm's experiments of air friction on a plane rectangular surface of sides a, l, where the speed V of the air is referred to the surface parallel to side l, the total frictional force upon a face is $F = 0{\cdot}000319\,a l^{0{\cdot}98} V^{1{\cdot}85}$. The equations deduced from this law for the present problem appear, however, to be very complicated, even when F is assumed to be proportional to the product al and to V^2.

The present author puts forward the following hypothesis to represent the effect of aerial resistance and friction in order to explain the different curves obtained by Carrière. The motion of the centre of gravity is the same as if this point were acted upon by its weight mg and a resisting force $R = mg\,\phi(V)$, increasing with the speed V and directed not in a contrary sense to the speed V, but making an acute angle α with the reverse vector to V, positive or negative according to the sense of rotation ω, varying with ω, and equal to zero when $\omega = 0$. The hypothesis implies that the action takes place as if the resistance R, being tangent to the trajectory and opposed to V when $\omega = 0$, is made to turn by the rotation ω through an acute angle α which is a function of ω and vanishes with it. Based on this hypothesis the author proceeds to develop the equations of motion, using Carrière's axes of coordinates, and then shows that his hypothesis affords a complete explanation of the particular trajectories recorded by Carrière. H. H. Ho.

329. *Theory of Lubrication.* **Rayleigh.** (Phil. Mag. 35. pp. 1–12, Jan., 1918.)—In this paper attention is given more especially to the case where one of the opposed surfaces is plane, but the second not necessarily so. As an alternative to an inclined plane surface, consideration is given to a broken surface consisting of two parts, each of which is parallel to the first plane surface but at a different distance from it. It appears from the analytical treatment here given that this is the form which must be

approached if we wish the total pressure supported to be a maximum, when the length of the bearing and the closest approach are prescribed. A sketch is given of a suggested arrangement for a footstep bearing. In a small model the opposed pieces were two pennies ground to a fit. One of these was afterwards grooved with a file, the grooves extending from the edge about two-thirds of the radius. Certain parts were then etched with dilute nitric acid, giving slight depressions of uniform depth. The two discs were mounted in a small cell, the upper one carrying an inertia bar. With oil as a lubricant the contrast between the two directions of rotation was very marked. A. W.

330. *Lubricating and Other Properties of Thin Oily Films.* **Rayleigh.** (Phil. Mag. 35. pp. 157–163, Feb., 1918.)—The experiments here described were undertaken to examine more particularly the fact that a cup of tea, standing in a dry saucer, is apt to slip about in an awkward manner, for which a remedy is found in the introduction of a few drops of water, or tea, wetting the parts in contact. A drop of liquid between two curved surfaces draws them together and so may increase the friction, but this does not avail to explain the effects now under consideration. The earlier experiments were made with a small glass bottle on a thick glass plate, which could be tilted until the bottle slipped. If the surfaces were perfectly clean, being thoroughly washed and rubbed under the tap and then dried by evaporation after shaking off as much water as possible, they were found to be "sticky" as compared with the condition after wiping with an ordinary cloth or after going over the surfaces with the fingers, not purposely greased. This is not surprising, but it is difficult to explain why, if the surfaces have been rubbed with the fingers or a cloth, making them relatively slippery, breathing on the glass slab or thoroughly wetting the contacts with water causes sticking again. More refined experiments with a small carriage standing on three hemispherical feet gave similar results. Using paraffin (lamp) oil it appeared that the friction was greater with a large than with a minute quantity of the same oil. Olive oil substituted for the paraffin gave results less strongly marked. It seems probable that the thickness of the greasy films on handled surfaces is comparable with the thickness of olive oil required to stop the camphor-movements on water, which Rayleigh found to be about 2×10^{-6} mm. The phenomena here in question thus lie outside the field of the usual theory of lubrication, where the layer of lubricant is assumed to be at least many molecules thick. The latter part of the paper deals with the question of impurities in regard to the behaviour of the thinnest films. A. W.

331. *The Energy Components of the Gravitational Field.* **E. Schrödinger.** (Phys. Zeits. 19. pp. 4–7, Jan. 1, 1918.)—In the gravitational theory of general relativity, the 16 quantities t^{α}_{σ}, which Einstein terms the energy components of the gravitational field, play a conspicuous part, especially for the purpose of introducing the energy tensor of matter into the field equations. The object of this paper is the explicit evaluation of the magnitudes t^{α}_{σ} in the vicinity of a sphere of incompressible gravitating liquid at rest. The calculation is performed for a spacial system of coordinates utilising Schwarzschild's values of $g_{\mu\nu}$. The system of coordinates must be specified for every evaluation of t^{α}_{σ}, since these quantities form no tensor and do not vanish alike in all systems for given data. In the author's opinion the results obtained are important aids towards a conception of the physical nature of the gravitational field. H. H. Ho.

332. *Mathematical Analogy between an Optical Problem concerning Moving Media and an Aeronautical Exercise.* **P. Frank.** (Phys. Zeits. 19. pp. 2-4, Jan. 1, 1918.)—For steering aircraft in the shortest time possible from point to point, given any arbitrary wind distribution, the most favourable course is generally not a straight line. The present paper contains an investigation of the curve to be followed for the most economic course. It is shown that the solution of the problem is exactly analogous to the optical case for the passage of light-rays through moving media, *e.g.* the earth's motion through the ether whereby an ether wind, relative to the earth, is brought into being, whose velocity may be determined by vector analysis. H. H. Ho.

333. *Experiments on Gravitation.* **P. Zeeman.** (K. Akad. Amsterdam, Proc. 20. 4. pp. 542-553, 1918.)—Various experiments are described here.

I. Spheres of quartz 127 gm. in weight are weighed with varying orientations of the optical axis. The weights found in different cases differ by less than 1 in 13,000,000.

II. Einstein's theory of gravitation requires exact equivalence of the inertia and the gravitative attraction of a body. In experiments made to test this point, a very delicate torsion balance after the design of that used by V. Eotvös was used. This work, at first attempted in Amsterdam, but, greatly disturbed by vibrations, was later carried out successfully in the country. In the case of quartz spheres it was found that the ratio of mass to weight differs from unity by less than 1 in 30,000,000. When one end of the torsion balance has quartz and the other end has lead oxide in a glass tube the ratio of mass to weight differs from unity by less than 1 in 20,000,000. When uranium oxide is used puzzling results are found which may be due to traces of iron. When, however, uranyl nitrate is used, the law of exact proportionality appears to be followed, the ratio of mass to weight differing from unity by less than 1 in 20,000,000. P. E. S.

334. *On the Two-dimensional Motion of Infinite Liquid produced by the Translation or Rotation of a continued Solid.* **J. G. Leathem.** (Phil. Mag. 35. pp. 119-130, Jan., 1918.)—Periodic conformal transformations—*i.e.* transformations by which doubly connected regions in the plane of a variable $z = x + iy$, externally unbounded and bounded internally by a closed polygon or curve, may be represented conformally and repeatedly upon successive semi-infinite strips of width λ in the half-plane $\eta > 0$ of a variable $\zeta = \xi + iy$—have already been studied by the present author. He has shown how knowledge of such a transformation for any particular curve makes possible the specification of a field of circulatory liquid flow (with or without logarithmic singularities) round a fixed solid body bounded by the curve. In the present paper it is proposed to show that such knowledge makes possible also the determination of the field of irrotational motion due to any translation or rotation of the same solid in surrounding infinite liquid. The field of flow due to translation of the boundary is first considered. Following this comes an evaluation of the impulse of the motion due to translation. Though modern speculation tends to regard wave-motion as the preponderating factor in suction and other inertia phenomena of floating bodies, it can hardly be doubted that, in the case of a submarine at least, the ordinary inertia coefficients measure approximately the resistance to quick changes of velocity. When the boundary has a motion of rotation, the specification of the liquid motion presents greater difficulty. The outline of the procedure adopted is as follows:—One motion is known which satisfies the proper condition at the moving boundary—namely, a rotation of the whole liquid, as if rigid, with the same angular velocity as the boundary. This may be called the "first motion." It is not the required motion, because it is rotational and has infinite velocity at infinity. A "second motion" can be specified which is also rotational, having the same vorticity at every point as the first motion; but at the boundary its normal velocity is zero and it has infinite velocity at infinity. If the second motion be subtracted from the first, the result is an irrotational motion whose normal velocity at the boundary is the same as that of the boundary itself. This may be called the difference motion. If the velocities of the first and second motions tend to equality at infinity in such manner that the difference motion tends to zero at infinity and has no circulation round the solid, the difference motion satisfies all the requirements of the problem, and is the motion due to the rotation of the solid. The various motions are mathematically investigated in the paper. H. H. Ho.

335. *Variably-coupled Vibrations: II. Unequal Masses or Periods.* **E. H. Barton** and **H. M[ary] Browning.** (Phil. Mag. 35. pp. 62–79, Jan., 1918.) —This second paper describes further experiments with the double-cord pendulum, but with the masses unequal as 20 : 1 and as 5 : 1, or the lengths unequal as 3 : 4. These are somewhat analogous to coupled electrical circuits with different inductances or different periods.

The case of masses 20 : 1 is seen to be very nearly that of forced vibrations in which the light bob is driven by receiving energy from the heavy bob or driver, while the latter's loss, though equal in energy, entails only a very small decrease of amplitude. The case of masses as 5 : 1 is about midway in character between that of 20 : 1 and equal masses. Eighteen photographic reproductions of double traces are given for unequal masses.

It was noticeable on one of the traces that the light bob showed diminution of amplitude as the trace proceeded. This led to taking resistance into account in the equation of motion. It was also necessary to determine experimentally the actual damping of the light bob when vibrating alone. The theory thus developed and numerically applied was found to fit the observed facts.

In the case of unequal lengths but equal masses, a feebler response and a shorter beat-cycle may naturally be expected than if mistuning were absent. Both these effects are quite striking with loose couplings. But with the tighter couplings the effect of mistuning is practically unnoticeable. The theory agrees with this experimental result. Nine sets of double traces are given for the unequal periods. [See Abs. 1221 (1917).] E. H. B.

336. *Anemometer Records on a Buffalo Office Building compared with those secured near the Surface of Lake Erie.* **B. C. Kadel.** (Monthly Weather Rev. 45. pp. 156–159, April, 1917.)—The Weather Bureau anemometer was mounted on a 40-ft. steel tower on the roof of a high building, the cups of the instrument being 280 ft. above the ground and 308 ft. above the level of the lake. The second anemometer used for the comparison was at the coastguard station about three-quarters of a mile to the SW., mounted on a steel tower 65 ft. above the lake. The shore line runs roughly north and south and the main part of the city lies to the east of the anemometers. The exposure to the W. and SW. is fairly open for both instruments. The results show that the lake shore anemometer recorded the greater velocity of the two with north winds only. With east winds it showed markedly less than the Weather Bureau instrument, and the same was true to a less extent with west and south-west winds. J. S. Di.

337. *Records at the Abbe Meteorological Observatory compared with those at the Government Meteorological Building, Cincinnati.* **W. C. Devereaux.** (Monthly Weather Rev. 45. pp. 224–231, May, 1917.)—The Abbe meteorological observatory stands on the summit of a hill with no other ground of so great elevation within two miles. The surrounding land is covered with trees. Government Building is in the low-lying part of the town and 900 yards from the Ohio River. It is surrounded by buildings of similar height to itself. The heights of the two anemometers above the ground are: Abbe Observatory, 51 ft.; Government building, 160 ft. Comparison of the wind records over two consecutive years shows some interesting features in the exposure of the instrument in the centre of the town. (1) S. winds tend to be deflected to SE. by a neighbouring roof; consequently an excess of SE. winds is shown on the records, whereas SW. is the prevailing wind of the district. (2) True NE. winds are often recorded as E. This appears to be due not to the neighbouring houses but to the deflection caused by a hill half a mile distant aided by the contour of the intervening land. (3) SW. winds tend to be deflected by local buildings into W. As regards velocity, in the winter, spring, and autumn the Abbe Observatory records the larger values, but in the summer a slight excess is found at Government Building, particularly on days with much sunshine. This is ascribed to the convective effect of the solar heating on the paved streets of the city. Comparison is also made of the temperature and other records at the two stations. J. S. Di.

338. *Accidental Pressure Variations in the United States.* **A. J. Henry.** (Monthly Weather Rev. 45. pp. 290–291, June, 1917.)—For ascertaining the number of rises or falls of pressure associated with the passage of depressions which occurred in a 10-year period, the difference between the pressure at station-level at 8 a.m. one day and that at the same station the next morning was tabulated, and the number of continuous periods of rising or falling pressure counted. Two stations were used on the Pacific coast, three in the Mississippi Valley, and two on the Atlantic coast. The chief conclusions are:—The number of pressure falls entering the United States on the Pacific coast is practically the same as that leaving on the Atlantic coast. The number is somewhat larger at northern stations than at southern. The max. number is found in winter with a suggestion of a secondary maximum in Aug. Along the northern boundary of the country falling pressure is succeeded by rising pressure after an interval of 24 hours or less in a little more than 50 % of the cases. In the southern part of the country there is a larger proportion of cases of pressure falling continuously for two days than in the northern. The mean of all 24-hour pressure-changes regardless of sign is found to diminish from north to south in a striking manner. J. S. Di.

339. *Some Researches in Far Eastern Seasonal Correlations.* III. **T. Okada.** (Monthly Weather Rev. 45. pp. 299–300, June, 1917.)—The relation between temperature in northern Japan in Aug. and the following elements in the preceding April is considered: (1) Pressure in SE. Canada. (2) Pressure in the Azores. (3) Pressure in Bermuda. (4) Pressure in Iceland. Also (5) the connection between the April pressure-difference Azores-Iceland (barometric gradient) and the air temperature of the following Aug. in northern Japan. The method employed is to count the number of cases in which the departures of the two elements from the normal are of the same sign and of opposite sign. By this means positive correlation is found in cases 1, 2, 3, and 5, and negative in case 4. In case 1 only is the correlation coefficient given, and here it is found to be small, + 0·32. J. S. Di.

340. *Distorted Solar Haloes.* **A. F. Hunter.** (Roy. Astron. Soc. Canada, J. 12. pp. 1–10, Jan., 1918.)—Describes certain abnormal haloes seen by the author and others. These were mostly either elliptic in shape or circular, but eccentric to the sun. Puts forward suggestions as to the method of formation of these haloes. J. S. Di.

341. *Photographs of a Tornado.* **H. E. Simpson.** (Monthly Weather Rev. 45. pp. 237–238, May, 1917.)—A destructive tornado passed within one mile of the town of Antler, North Dakota, on the evening of Aug. 20, 1911. This region is outside the limits of the usual tornado tracks and few have previously been reported. Some excellent photographs of the tornado cloud were obtained as it passed the town and these are reproduced in the original article. J. S. Di.

342. *City Smoke and Daylight Illumination Intensities.* **H. H. Kimball** and **A. H. Thiessen.** (Monthly Weather Rev. 45. pp. 205–207, May, 1917.)—In order to determine the diminution of daylight illumination on a horizontal surface produced by the smoky atmosphere of towns, photometric measurements were made on four cloudless days in Salt Lake City, on two of which the air was clear while on the other two it contained much smoke. It appears that with sun's zenith distance = 55° on a smoky day the total illumination is about two-thirds and the direct solar illumination about one-half what it is on a clear day, while the diffuse illumination from the sky only (the instrument being shielded from the sun) is about $1\frac{2}{3}$ times the illumination from a clear sky. With increase in the sun's zenith distance the diminution in the total and in the direct solar illumination is greatly intensified while at the same time the increase in the intensity of diffuse skylight becomes less marked. J. S. Di.

343. *Tornadoes and Windstorms of May 25–June 6, 1917.* **H. C. Frankenfield.** (Monthly Weather Rev. 45. pp. 291–298, June, 1917.)—A number of depressions of the Colorado or south-western type moved north-eastward across the United States between May 17 and June 8, 1917. Until May 20th temperatures were low to the south and south-east and no storms of the tornado type developed, but the remainder of the period was characterised by very numerous tornadoes which are here described in detail. A map is reproduced showing the tracks followed. In all, more than 350 lives were lost and $10,000,000 worth of damage done to property. J. S. Di.

344. *Snowfall of New England.* **C. F. Brooks.** (Monthly Weather Rev. 45. pp. 271–285, June, 1917.)—The heavy snowfall of the winter of 1915–1916 in the New England region of the United States led to this inquiry into other cases of heavy falls. In the winter named over 100 inches fell in the higher inland regions, and only a little less than this depth down to the coast. These large amounts were due rather to frequent falls throughout Feb. and March than to any one or two snowstorms of exceptional magnitude. Charts are given showing the distribution of the fall in this and other outstanding winters with also the mean seasonal distribution. Mean monthly falls and the results for certain exceptional months are also shown by charts. February is the month of greatest snowfall.

The conclusion is reached that the tremendous New England winters of long ago were no more numerous, and with two exceptions no more snowy than at the present time. The exceptions noted are the winters of 1716–1717 and 1786–1787. The mountainous character of parts of the country makes the study of the "snow shadows" in the lee of mountain ranges a matter of interest. J. S. Di.

345. *Limiting Strength of Rocks in the Earth's Interior.* **L. V. King.** (J. of Geology, 25. pp. 638–658, Oct.–Nov., 1917.)—Experiments by Adams and Bancroft on the behaviour of rocks when stressed in nickel steel cylinders are discussed. There is an elastic stage, succeeded by a plastic stage during which the rock flows continuously. During the elastic stage the principal shear stresses are independent of the radius and remain equal. Therefore, from Tresca's theory, the rock will commence to flow simultaneously throughout its volume. The plastic stage begins in the softer rocks at a definite shear stress (the modulus of plasticity), and such rocks give a definite coefficient of internal friction. The harder rocks have no definite constants, but the friction is high. It was found that in order to keep the rock continually flowing, the shear stress had continuously to be raised. Thus the resistance to flow increases with the hydrostatic pressure, or, in the earth's crust, with the depth. Theories of isostasy should take into account this increasing stiffness; also continental elevations much greater than those existing are possible. This increasing stiffness shows that the region of flow would be comparatively near the surface. All great earth movements have proceeded by continuous adjustment and not by a series of collapses. Experiments on the effect of temperature upon internal friction are wanting. W. A. R.

346. *On the "Laufzeitkurve" for Near Earthquakes.* **S. Nakamura.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 224–234, Jan., 1918.)—Since Oldham first tried to draw the *Laufzeitkurve,* it has been reconstructed by many authors with some degree of accuracy, but the curve for the region near the epicentre is less accurate, though exceedingly important for the study of the mechanism of earthquake origin. In Japan valuable data for near earthquakes have been accumulated, and the present author has been enabled to draw the curve for the region about the epicentre with much greater accuracy than was formerly possible. He commences by an extension of Wiechert's treatment of the *Laufzeitkurve,* pointing out the modifications to be introduced for near earthquakes. Since the assumption that the earthquake origin is at the surface of the earth is not admissible in the latter case, the problem is insoluble unless a relation be assumed between the velocity of the waves and the depth of the layer into which the waves propagate. The latter necessity is considered in detail in the paper in connection with the available seismic data. Numerous tables accompany the paper. H. H. Ho.

347. *Explanation of a supposed Abnormal Solar Spectrum.* **G. E. Hale.** (Mt. Wilson Solar Observat., Contrib. No. 143. Astrophys. J. 46. pp. 291–295, Nov., 1917.)—Two photographs of the solar spectrum obtained in 1894 at the Kenwood Observatory, Chicago, appeared to show abnormalities, and the idea was entertained that they were due to chance superposition of two spectra of two different orders [Astrophys. J. 16. p. 220, 1902]; the absence of the bright H and K reversals and other causes, however, led to this explanation being dismissed. A letter is now published from F. E. Baxandall showing that the spectra can be satisfactorily explained by the superposition of a first-order on a third-order spectrum, several groups of wave-lengths being quoted in evidence. Hale is now quite satisfied that this is the correct explanation, as the plates were among several made in parallel strips on a single plate for testing exposure times required for spectra of different orders. C. P. B.

348. *Temperature and Radiation of the Sun.* **F. Biscoe.** (Astrophys. J. 46. pp. 355–357, Dec., 1917.)—Answering a criticism by Abbot, Fowle, and Aldrich [Abs. 757 (1916)] of an article by the author, Biscoe points out that his neglect of scattering involves only that part of the scattered light in the earth's atmosphere which enters into the direct solar beam and reaches the observer; this is only comparable to the brightness of the earth's atmosphere as compared with the brightness of the sun; in the case of the solar atmosphere, similarly, only its brightness compared with that of the photosphere. The supposition of a black radiation for the photosphere appears well founded from the agreement of the deduced distribution of energy in the spectrum of the solar photosphere with that in the spectrum of a black body of known temperature. With regard to the variations of solar constant, it is pointed out that the observations depended on observed coefficients of transmission of the earth's atmosphere, which were affected in their turn by the eruptions of Mount Katmai. Biscoe did not seek to show that real variations in the radiation of the sun are not possible, but that it was very difficult to prove it. C. P. B.

349. *Solar Hydrogen "Bombs."* **F. Ellerman.** (Mt. Wilson Solar Observat., Contrib. No. 141. Astrophys. J. 46. pp. 298–300, Nov., 1917.)—On 1915 Sept. 21, while observing the Hα line for reversals and distortion in an active spot group, there suddenly appeared a brilliant narrow band extending four or five Ångströms on either side of the line, but not crossing it. The appearance faded away in a few minutes. Since then other observations of the phenomena have been made and photographically recorded. The suggestion is that something in the nature of an explosion is occurring, hydrogen alone being concerned. W. M. Mitchell appears to have noted an object of this nature in his observations at Haverford [Abs. 2008 (1909)], and he records it as being visible also in D_3 (helium). In general the band appears symmetrical on each side of the Hα line, but in a few cases it has been more greatly extended on the violet side; never on the red. The regions where these bombs occur are generally around and among active spot groups, at the outer edge of penumbra or between spots. Photographs of the phenomenon are reproduced. C. P. B.

350. *Luminosities and Parallaxes of 500 Stars.* **W. S. Adams** and **A. H. Joy.** (Mt. Wilson Solar Observat., Contrib. No. 142. Astrophys. J. 46. pp. 313–339, Dec., 1917.)—A list of 500 stars is given with their absolute magnitude and the values of parallax as determined by the spectroscopic method [Abs. 752 (1917)] and by the usual trigonometrical method, showing the former to be about +0·004″ larger in the mean. If all parallaxes are included, the average difference is 0·026″, while comparison with 59 parallax values determined by three or more observers gives a difference of +0·001″ in the mean. Modifications in the method have been adopted for certain types of stellar spectra from A_8 to F_5, rendered necessary by the small variation shown by the calcium line at λ4455. For these stars three other lines have been found satisfactory: the two strontium lines λλ4215, 4077, and a line at λ4290, probably chiefly due to enhanced titanium. Some difficulty was found with the giant M-type stars, the most satisfactory treatment being comparison of the spectrum of each star with that of α Orionis, probably the most highly luminous star of this type. Comparison of the number of stars

of each absolute magnitude clearly shows the giant and dwarf divisions for the M, K, and, probably, G types of spectrum, with a slight indication even for the F stars. The lines used for the determinations of absolute magnitudes are those which in laboratory sources show marked variations with vapour-density and temperature. Lines strong in highly luminous stars are strong in the electric spark; those strong in the fainter stars are strong in the electric furnace. In the spectra of the highly luminous stars the hydrogen and enhanced metallic lines are abnormally strong. C. P. B.

351. *Colour Curve and Light-elements of W Ursæ Majoris.* **H. Shapley and J. Van Der Bilt.** (Mt. Wilson Solar Observat., Contrib. No. 140. Astrophys. J. 46. pp. 281–290, Nov., 1917.)—A paper on the orbit of this star, interesting because of its exceptionally short period of four hours between minima, has been published by Russell and Shapley [Abs. 1107 (1917)]. The present communication contains a discussion of the preliminary Mount Wilson observations, showing that the colour index is in agreement with its spectral type (G), and that there is no conspicuous change of colour between minimum and maximum light. The times of six minima have been determined from a series of photometric measures made at the Utrecht Observatory. A small perturbation of the period is indicated from the study of 64 minima, but more observations are necessary for finding the details. C. P. B.

352. *Stellar Magnitude Scales of Astrographic Catalogue.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 78. pp. 54–64, Nov., 1917.)—Further material for the intercomparison of the magnitude scales of the Astrographic Chart is obtained by the receipt of results from Cordoba (— 25°) and Tacubaya (— 15°). C. P. B.

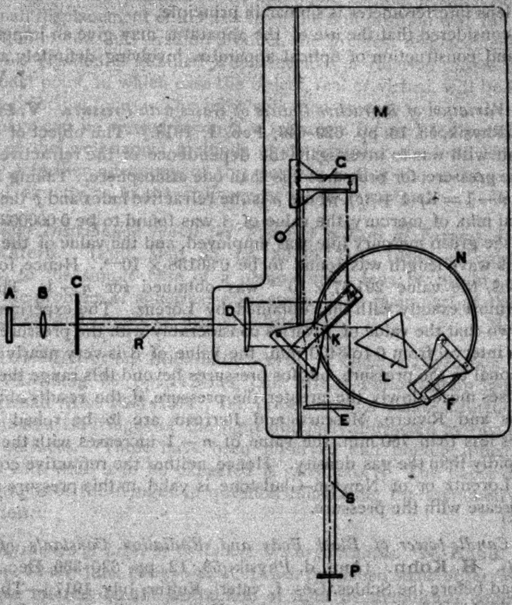
353. *Number and Galactic Distribution of the Stars.* **S. Chapman.** (Roy. Astron. Soc., M.N. 78. pp. 66–77, Nov., 1917.)—Attention having been called by van Rhijn to an error in treatment of the star-counts in the discussion of counts of stars on Franklin-Adams photographs, published by Chapman and Melotte [Roy. Astron. Soc. Mem. 60. p. 145], the observations are shown to give values of the galactic condensation in fair agreement with other determinations when reduced in proper form, and the increase in galactic condensation for faint stars may now be regarded as established. C. P. B.

354. *Aurora and Magnetic Storm of March* 7–8, 1918. (Nature, 101. p. 32, March 14, 1918.)—This aurora, which attracted especial attention on account of its coincidence with an air raid on London, was seen at widely scattered stations over the British Isles from Lerwick in the north to Southend and Folkestone in the south. It was associated with a magnetic storm which was possibly a repetition after three 27-day intervals of the storm of Dec. 16–17, 1917 [see Abs. 306 (1918)]. There was a display of aurora on the occasion of this earlier storm. Magnetic disturbances occurred at the end of each of the intermediate 27-day intervals. The present storm gave a range of 240 γ in horizontal force and 51′ in declination. J. S. Di.

LIGHT.

355. *Differential Spectrophotometer.* **G. A. Shook.** (Astrophys. J. 46. pp. 305–312, Dec., 1917.)—A spectrophotometer is described as applied to observations of varied kinds, including colorimetric and pyrometric work. The special feature is a differential double slit worked from a single micrometer screw, whereby the slit widths can be altered simultaneously by equal amounts in opposite directions, the sum of any width in use being constant.
C. P. B.

356. *Interferometers for the Examination of Optical Systems.* **F. Twyman.** (Phil. Mag. 35. pp. 49–58, Jan., 1918.)—Describes two forms of interferometers for the examination, respectively, of optical combinations which are required (i) to receive a beam of light which has a plane wave-front and deliver it again after transmission with a plane wave-front; or (ii) to impart spherical wave-fronts to beams which are incident on them with plane wave-fronts. These two arrangements are referred to as the prism interferometer and the lens interferometer respectively. The former is shown in the Fig. as arranged for the correction of a 60° prism such as is used for spectroscopy. Monochromatic light from the source is reflected by the adjustable mirror A through the condensing lens B by means of which it is condensed on the aperture of the diaphragm C. The diverging beam of light is collimated by a lens D and falls as a parallel beam on a plane parallel plate K, the second



surface of which is silvered lightly, so that a part of the light is transmitted and part reflected. The greater part should be reflected. One part passes through the prism L in the same way as in actual use, and, being reflected by the mirror F passes back through the prism to the plate K. The other part of the light is reflected to the mirror G and back again to the plate K. Here the separated beams recombine, and passing through the lens E each forms on the eye placed somewhat beyond the aperture Z in the diaphragm P an image of the hole in the diaphragm C. When the mirrors are adjusted, interference bands are seen which form a contour map to a scale of wave-lengths of the extent to which passage of the beam twice through the prism has distorted the wave-front. This distortion can be corrected by removing from each point of one prism face, by local polishing, an amount of glass proportional to the distortion of the wave-front at that point; hence it follows that the bands also form a contour map of the glass requiring to be removed in order to make the optical performance of the prism perfect.

The lens interferometer is similar in principle.

It is considered that the use of the apparatus may give an impetus to the design and construction of optical apparatus involving definitely aspherical surfaces. J. W. T. W.

357. *Variation of Refractive Indices of Gases with Pressure.* **V. Posejpal.** (Ann. d. Physik, 53. 16. pp. 629–646, Feb. 1, 1918.)—The object of the work here dealt with was to investigate the dependence of the refractive index of air on the pressure, for pressures less than one atmosphere. Taking Mascart's formula $n - 1 = Kp(1 + \beta p)$, where n is the refractive index and p the pressure in normal mm. of mercury, the value of β was found to be 0·00000396. The light of the green mercury line was employed, and the value of the constant K for this wave-length was found to be $0·36138 \times 10^{-6}$. Hence, for normal conditions, the value $291·67 \times 10^{-6}$ was obtained for $n - 1$. This result agrees almost exactly with that obtained by Lorenz. The experiments have also shown that the value of β varies considerably with the pressure. In the pressure interval from 0 to 3400 mm. the value of β is very nearly inversely proportional to the pressure, but for pressures beyond this range the value of β decreases more slowly the greater the pressure, if the results obtained by Chappuis and Rivière, Mascart, and Perreau are to be relied on. For pressures less than 760 mm. the value of $n - 1$ increases with the pressure more rapidly than the gas density. Hence neither the refractive constant of Lorenz–Lorentz or of Newton–Gladstone is valid in this pressure interval; both increase with the pressure. A. W.

358. *Candle-power of Black Body and Radiation Constants of Carbon Filaments.* **H. Kohn.** (Ann. d. Physik, 53. 12. pp. 320–336, Dec. 14, 1917. Paper read before the Schles. Ges. f. vaterl. Kultur, July, 1917.)—The brightness of the black body was measured (in Hefner candles per cm.²) at various temperatures, by comparison with a carbon-filament standard lamp. The brightness at 2000° abs. was obtained by extrapolation according to the Rasch equation, giving the value 12·75 m.s.c. per cm.² assuming the value 1·45 for the Wien constant c_2. Using this result, the efficiency of the black body (m.s.c. per watt) at 2000° abs. is found to be 0·148 at the same value of c_2. Finally from these values the radiation constants of carbon lamp filaments are found. J. W. T. W.

359. *Minimum Radiation Visually Perceptible.* **H. Buisson.** (Astrophys. J. 45. pp. 296–297, Nov., 1917.)—Results of determinations of the

limits of sensibility of the eye are given in relation to the previous papers on the subject by H. E. Ives [Abs. 128 (1917)] and H. N. Russell [Abs. 767 (1917)]. The measurements were made on faint phosphorescent screens of ZnS excited by a radium salt, which were compared with a film diffusing by transmission a light of known intensity, by a person having ordinary vision after remaining in darkness for about 15 mins. The results are very consistent, indicating a max. distance of 27 km. as that at which a candle would be visible. Assuming that a candle at one km. is of stellar magnitude 0·82, it is deduced that the limit of visibility would be a star of magnitude 8·0, corresponding to receipt of energy by the eye of $1{\cdot}25 \times 10^{-9}$ erg. per sec.
C. P. B.

360. *Nodal Slide Method of Focometry.* **J. A. Tomkins.** (Phil. Mag. 35. pp. 21–27, Jan., 1918.)—An examination of the null method of focometry described by A. Anderson [see Abs. 215, 488, and 1122 (1917)] with the object of determining the best position of the null point, *i.e.* that position for which a given small displacement of the axis from the null position will, for a given small rotation of the lens system, produce the greatest displacement of the image. This position is attained when the axis of rotation passes through the first nodal point, in which case the object, real or virtual, will be situated at the first principal focus. The light will then emerge as a parallel pencil, and the image can be viewed through a telescope focused for parallel rays, as in one of the well-known methods of determining the focal length of a thin lens. A further advantage of this position is that the nodal points are determined directly as in the ordinary nodal slide method. J. W. T. W.

361. *Light Distribution round the Focus of a Lens at Various Apertures.* **L. Silberstein.** (Phil. Mag. 35. pp. 30–49, Jan., 1918.)—A worked-out application to the simple case of a plano-convex lens of Strehl's general results on the problem of spherical aberration. The main part of the paper is mathematical and cannot be usefully abstracted. J. W. T. W.

362. *Asymmetry of the Illumination-curves in Oblique Diffraction.* **S. K. Mitra.** (Phil. Mag. 35. pp. 112–119, Jan., 1918.)—Following up some work by C. V. Raman [Abs. 1698 (1911)] the present author makes a further study of the asymmetrical fringes of the light obliquely diffracted by two parallel reflecting surfaces. These have been observed and photographed. The agreement with what is to be expected is satisfactory. The paper contains six photographs of the fringes in question illustrating the asymmetry under consideration. E. H. B.

363. *Diffraction of Light by Cylinders of Large Radius.* **N. Basu.** (Phil. Mag. 35. pp. 79–97, Jan., 1918.)—C. F. Brush published some observations of considerable interest on the diffraction of light by cylindrical edges. But the views put forward by him to explain the phenomena present serious difficulties and seem open to objection. The object of the present work was to find the true explanation of the effects, and to develop a mathematical theory which would stand a quantitative test in experiment. This has now been done, the following being the principal conclusions reached :—(1) The fringes seen in the plane at which the incident light grazes the cylinder are due to the simple interference of the direct and the reflected rays, the positions of the dark bands being given by the formulæ $x = \frac{3}{4}(2a)^{1/3}(n\lambda)^{2/3}$. (2) The fringes in a plane further removed from the source of light than the cylinder are due to diffraction at the edge grazed by the incident rays but modified by interference with the light reflected from the surface of the cylinder. The positions of the dark bands in these fringes are (to a close approximation) given by the formulæ $x = 2d\theta + 3a\theta^2/2$, and $n\lambda = 2d\theta^2 + 2a\theta^3$, from which θ is to be eliminated. (3) When the focal plane of the observing microscope is on the side of the cylinder towards the light, the direct and reflected rays do not cover exactly the same part of the field, and by putting the focal plane sufficiently forward towards the light, they may be entirely separated. When this is the case, the fringes of the ordinary Fresnel type due to the edge of the cylinder may be observed, and inside the shadow we have also an entirely separate system of fringes due to the reflected rays, the first and principal maximum of which lies alongside the virtual caustic formed by oblique reflection. The distribution of intensity in this system can be found from the well-known integral due to Airy.

A set of eight photographs of the various fringes is included in the paper.
E. H. B.

364. *The Use of Moll's Thermopile for Absolute Measurements.* **N. H. S. van Reesema.** (K. Akad. Amsterdam, Proc. 20. 4. pp. 566–572, 1918.)—The paper is a preliminary communication describing the procedure followed in calibrating the thermopile used for measuring light-absorption in photochemical researches. This calibration was carried out in the following manner: A thin blackened plate of Pt was slid in front of the pile and a measured electric current sent through it producing a certain deflection of the galvanometer attached to the pile. Next a beam of light from a constant source was thrown on the plate and the deflection noted. The plate was then removed and the same beam thrown directly on the face of the thermopile. From the data obtained it was possible to calculate the quantity of energy required to impart unit deviation to the galvanometer attached to the pile.
E. G.

365. *Spectral Selectivity of Photographic Deposits.* **L. A. Jones** and **R. B. Wilsey.** (Eastman Kodak Co.'s Research Lab., Comm. No. 57. Phot. J. 58. pp. 70–81, Feb., 1918. Frank. Inst., J. 185. pp. 231–267, Feb., 1918.)—It is well known among practical photographers that the colour of the silver deposit in a photographic negative exerts a marked influence upon the quality of the resulting print. Thus, negatives made with certain developers exhibit decidedly yellowish deposits, while other developers produce images that are entirely colourless. Of two such negatives having the same visual quality except for the differences in colour, the yellowish one will produce a print of decidedly greater contrast. The reason for this is immediately apparent upon consideration of the differences between the visibility function of the eye and the spectral sensibility (analogous to the visibility function) of the photographic printing material. The maximum of the visibility function lies at 554 $\mu\mu$ in the green region of the spectrum, while the maximum of the photographic spectral sensibility is located in the violet between 380 $\mu\mu$ and 440 $\mu\mu$, the exact location varying between these limits for different sensitive materials. A deposit which is yellowish, that is, having excessive absorption for radiation of the shorter wave-lengths, therefore, will have a lower total transmission when measured by using some photographic material as a receiving surface for the transmitted radiation than when measured by a visual method in which the retina of the eye is employed as the light-sensitive receptor. Since the conception of photographic transmission as distinguished from visual transmission of such deposits is more or less new, it seems desirable, for the sake

of clearness and uniformity in the terminology of future work to be done along this line, to define and name certain of the terms involved, and to outline experimental methods for their measurement. The relations existing between the visual and photographic characteristics of a negative and the methods of measuring those relations are considered in detail. Methods for estimating effective printing density are next dealt with. In general three groups of data from which three curves may be plotted are required for a solution of this problem. They are as follows: (*a*) The visual density values for the various areas of the sensitometer strip and the corresponding exposure values. (*b*) The density values from a contact print made from the negative strip on the positive material for which the effective printing density values of the negative deposits are desired. (*c*) The density values from a strip of the positive material exposed in the sensitometer and developed along with the contact prints, and the values of the exposures given by the sensitometer to the various areas of this strip. Two methods of reducing the data are presented, differing slightly in detail. The method most applicable to any particular case will depend upon circumstances and upon the results desired. No effort has been made to present quantitative date, and such statements as are given regarding the characteristics of materials should be regarded as approximate, being introduced only for the sake of illustration. Also it is impossible to deal with all the details of the practical application of the methods discussed. Such a detailed discussion will be given in other sections of this paper, which will appear later, dealing with the application of these methods to specific cases [see next Abs.]. A large amount of data on the spectral sensibility of positive materials and on the colour coefficient, χ, of negatives produced by the use of various developing agents has already been obtained and will be presented in a later section of the series of which this paper is the first. A. E. G.

366. *Sensitometry of Photographic Intensification.* **A. H. Nietz** and **K. Huse**. (Eastman Kodak Co.'s Research Lab., Comm. No. 58. Phot. J. 58. pp. 81–91; Disc., 91–93, Feb., 1918. Frank. Inst., J. 185. pp. 389–408, March, 1918.)—It is well known that when a negative is intensified the intensified deposit is often of a colour different from that of the original negative, and that this colour affects the printing quality of the intensified negative; in fact, some processes of intensification depend entirely upon a change of the silver to some material having a more non-actinic colour. For instance, if a negative is bleached to a silver salt and then treated with sulphide solution, the silver will be converted into silver sulphide and visually will be more transparent than it was before the treatment, but the colour of the silver sulphide deposit will be a brown, having much more opacity for blue light than the silver, and, consequently, when printed, the negative will give a print with more contrast. While intensification has been dealt with in photographic literature from the chemical standpoint and also in regard to the practical advantages and disadvantages of various methods, very little quantitative work has been done on the effect of the colour of the deposit. A bibliography of the work on the subject of intensification published during the last 17 years is appended. An account is given of a series of measurements made on the effective printing contrast of negatives intensified by various processes, the intensified negatives ranging from those practically neutral in colour to very highly-coloured deposits. Twenty well-known formulæ are investigated. The visual and the photographic effects are considered in detail with the aid of curves. Classes of intensification;

the character of the photographic intensification; and the colour coefficients of intensifiers form important sections of the paper. Four typical negatives requiring intensification are discussed, bearing in mind that the primary object of the process is the increase of photographic contrast in the negative to produce prints of the best quality possible. (1) Average landscape, over-exposed, and undeveloped to save the negative. (2) Average landscape, under-exposed, but having faint detail. (3) A line subject in black and white, typical dry-plate process work. (4) A pyro negative of high colour of any of the preceding kinds. Errors in methods are also discussed. A. E. G.

367. *Photographic Resolving Power.* **K. Huse.** (Abstract of Eastman Kodak Co.'s Research Lab., Comm. No. 61. Optical Soc. of America, J. p. 119, July, 1917. Frank. Inst., J. 185. pp. 277–278, Feb., 1918.)—Photographic resolving power is defined in terms of the distance by which two minute images lying adjacent to one another must be separated in order that, when photographed, they may be distinguishable as separate images and may not merge into one in consequence of the grain structure of the emulsion. The object of this investigation is to determine the influence of the specific factors exposure, development, and wave-length of light on the photographic resolving power. The method employed consists of photographing a fan-shaped converging grating in a reducing camera, fitted with a highly corrected telescopic objective. The measurements of the minute images thus formed are made on a micrometer microscope. Since the spacing of the grating and the scale of reduction are known, a numerical expression for resolving power is found. The sensitive material used is Seed lantern plates. The errors involved in the method, due to the use of a lens and to the fact that the measurements introduce the personal equation to a certain extent, are proved negligible. The results of experiments on the effect of exposure show that resolution is extremely sensitive to this factor, there being a critical value where best resolution is manifested; serious over- or under-exposure is detrimental. It is also found that there is an optimum time of development for best resolution, so that it seems that an exposure such that the densities lie on the straight line portion of the characteristic plate curve, and development to a gamma of unity, yield highest resolving power. Investigation shows that the reducer or the developer employed has great bearing on resolution. Twenty developers are tried. The results obtained show resolution values varying from 47 to 77 due to the developer. With regard to the effect of the wave-length of the incident light, resolution is best for light of short wave-lengths, the resolution decreasing to a minimum in the green and increasing again in the red, though not to so high a value as with the blue light. In these experiments three types of photographic emulsions—ordinary, orthochromatic, and panchromatic—were used. A. E. G.

368. *Interference Colours of Quartz and Sodium Chlorate in Polarised Light.* II. **T. Liebisch** and **A. Wenzel.** (Preuss. Akad. Wiss. Berlin, Ber. 52. pp. 777–807, 1917.)—Describes an elaborate investigation of the interference colours obtained with various plates and wedges of quartz and sodium chlorate in a parallel beam of polarised light between crossed nicols. The chief interest of the paper lies in the numerous diagrams and tables of results. [See Abs. 938 (1917).] A. W.

369. *Structure of Mercury Line* $\lambda 2536$. **L[ucy] Wilson.** (Astrophys. J. 46. pp. 340–354, Dec., 1917.)—An interferometer of the Fabry and Perot type was employed for investigating the structure of the ultra-violet mercury line at λ2536·72, the plates being coated with electroplated Ni upon a kathodic foundation of the same metal. This type of reflecting surface was chosen after numerous experiments with other metals, the details of which are given. The result of the inquiry is that the λ2536 mercury line is a doublet, the components of which are separated by 0·014Å. An instrument of greater efficiency would be necessary to determine any possible greater complexity of the line structure. C. P. B.

370. *Spectrum of Titanium.* **A de Gramont.** (Comptes Rendus, 166. pp. 94–99, Jan. 21; *Errata*, p. 192, Jan. 28, 1918.)—A continuation of previous work [Abs. 1580 (1914)] on the ultimate lines in the dissociation spectra of various elements. The investigation has been confined mostly to the study of metals presenting some industrial interest, on account of their employment in certain special steels. The metal here dealt with is titanium, and the method of investigation was the same as in the earlier work. Definite small proportions of some compound of the metal were fused with a certain quantity of one of the alkaline carbonates and the spark spectra of the resultant mixtures were then examined both visually and photographically. Titanium itself was first examined and then specimens of columbium (niobium) were dealt with, since the spectrum of this metal always contains, more or less developed, that of titanium. It is almost impossible to eliminate the Ti spectrum completely. Photographs of the spectra are reproduced and tables are given of the lines persisting with various degrees of dilution of the Ti in the flux employed. The three lines λ3372·80, λ3361·22, and λ3349·41 are shown photographically when the proportion of Ti is only 2/100 000, the middle line of the three being the P line of the solar spectrum. The line λ3349·41 was obtained when the proportion of Ti in the flux was only 1/100 000. Altogether 14 groups of lines are included in the tables given, and of these all the lines in the region λ4748 to λ2882 are affected by powerful magnetic fields. This was the region investigated by Purvis [Abs. 832 (1907)]. The persistence of the various groups can be utilised for the rapid spectroscopic analysis of steels containing small proportions of Ti, following the same procedure as developed previously for vanadium, molybdenum, and tungsten steels. A similar method is applicable to the study of minerals containing titanium. A. W.

371. *Ratio of the Intensities of the D-lines.* **V. Voss.** (Phys. Rev. 11. pp. 21–28, Jan., 1918.)—It has been known for a long time that the ratio of intensities of the D-lines varies with the intensity of the sodium flame. Some observations by Wood [Abs. 1250 (1914) indicated that, for an exceedingly weak flame, the ratio attained as high a value as 3 or 3·5. This estimate was made by comparing photographs made with different times of exposure, and it was assumed that the blackening of the photographic plate was directly proportional to the time of exposure. In the present work three methods have been employed: (i) A photographic method, based on the use of a sectored disc. (ii) A visual method, in which the intensities were made equal by a polarisation arrangement. (iii) A visual method in which screens, having known coefficients of absorption, were used.

The experiments show that the max. value for the ratio of the intensities is $D_2/D_1 = 2$, which is correct to within 10 %. A. W.

372. *Spectrum of Nickel.* **J. E. Paulson.** (Phys. Zeits. 19. pp. 13–15, Jan. 1, 1918.)—Many of the lines in the spectrum of nickel can be arranged

in groups with constant frequency differences. The present paper gives in tabular form a number of these groups, which include most of the strong lines. From λ4715, where the measurements of Exner and Haschek begin, there is only one line of intensity 20, two of intensity 15, three of intensity 10, and five with intensity 5 which do not occur in the tabulated groups, while 57 lines with intensity equal to or greater than 5 are included. Only the arc spectrum is here dealt with, the measurements of Stütting, Hasselberg, and Exner and Haschek being used. A. W.

373. *On Certain Absorption Bands in the Spectra of the Uranyl Salts.* **H. L. Howes.** (Phys. Rev. 11. pp. 66–69, Jan., 1918.)—In a brief historical sketch the author points out that Stokes was probably the first investigator to notice that the fluorescence and absorption spectra of the uranyl salts are slightly overlapped. Morton and Bolton also noticed coincidences in the position of several fluorescence and absorption bands of the uranyl salts, while several were found by Becquerel and Onnes working at low temperatures. Nichols and Merritt found that the "reversing region" was of considerable length; in the case of uranyl potassium sulphate they were able to reverse the brilliant fluorescence band at 5180 Å.U., whereas previously the reversals had been limited to the region beyond 5000 Å.U. In their study of the uranyl double chlorides E. L. Nichols and the author found it possible to reverse a complete group of fluorescence bands lying between 5080 and 4880 Å.U. The desire to extend this "reversing region" towards the red led the author to undertake the present investigation. A theory of luminescent radiation recently proposed by E. H. Kennard also made the investigation of interest. Certain experimental details are given in the paper. The four salts studied were the uranyl chlorides of potassium, ammonium, rubidium, and caesium. Two tables of results, at +20° C. and −185° C. respectively, are given. At +20° almost all of the new bands fall into fluorescence series, while at −185° the new bands generally fall in the absorption band series. The present study has added the reversals of two complete groups. For some reason the bands cannot be traced as far into the red when the crystal is cooled to −185° C. It is evident from the results that Stokes' law does not hold, and it may be that every fluorescence band has an absorption band of the same wave-length. H. H. Ho.

374. *Resonance Radiation of Sodium Vapour excited by One of the D-lines.* **R. W. Wood** and **F. L. Mohler.** (Phys. Rev. 11. pp. 70–80, Jan., 1918.)—The arrangement of the apparatus and the method used in the work here described differed only in minor details from the method of Wood and Dunoyer [Abs. 1527 (1914)]. It was found that the presence of hydrogen in the bulbs causes both D-lines to appear when resonance is excited by one D-line only, the effect being similar to that of helium in the case of the iodine resonance spectrum. It is concluded that the transfer of energy from the D_2 to the D_1 emission centres, or *vice versa*, is in some way the result of molecular collision, either of sodium with hydrogen, or of sodium with sodium. In a bulb of pure sodium at 220° the surrounding vapour is not dense enough to have an observable effect on the radiation centres, and only one line appears in the resonance spectrum. The appearance of the other line results from an increase in the collision frequency, which increase can be caused either by the introduction of hydrogen at low pressure or by increasing the density of the Na vapour. A. W.

375. *Resonance Spectra of Iodine.* **R. W. Wood.** (Phil. Mag. 35.

pp. 236–252, March, 1918.)—Describes further work on the resonance spectra of iodine [Abs. 224 (1914)]. By the use of dicyanine plates the doublet series has now been followed to its termination at λ7685; the seven new doublets have also been accurately measured. The doublets are not all of uniform intensity, and some are missing entirely, and it is the connection between this circumstance and the way in which the doublet series is related to the band absorption spectrum that is the most interesting point brought out by the recent investigations. By varying the conditions of the experiment it has been found possible to excite by the green mercury line not only the doublet series but a simplified system of fluted bands, few in number and regularly spaced if the iodine is *in vacuo*, increasing in number and complexity if a gas of the helium group is mixed with the iodine, or if more than a single iodine absorption line is excited by the mercury lamp. It is probable that the lines forming the doublets are themselves constituents of the fluted bands, and the transfer of energy from one part of the vibrating system to another, as a result of collisions between iodine and helium molecules, enables us to build up, so to speak, the complicated system of fluted bands shown in the absorption spectrum, out of a number of simpler systems which can be excited separately. This constitutes a very great advance in the analysis of band spectra, and brings us a step nearer to the point at which we can picture some idea of the vibrating system. In the more recent work a method of illumination has been employed which is distinctly superior to any previously used, and this is described in detail. The paper is illustrated by a number of diagrams and photographs. A. W.

376. *Series Law of Resonance Spectra.* **R. W. Wood and M. Kimura.** (Phil. Mag. 35. pp. 252–261, March, 1918.)—This paper deals with the measurements of wave-length of the lines in the groups of the iodine resonance spectra, and with the series law which governs their spacing. The series which has been most definitely determined is the series of strong doublets excited by the Cooper Hewitt lamp. The table of wave-lengths establishes the fact that, while the separation of the components of the doublets increases progressively from 1·51 Å.U. at 0 order to 2·5 Å.U. at the 27th order, the frequency difference between the components is a constant, 50. The following formula, applying to the first member of each doublet (short wave-length component), represents the series well as far as the 15th order: $1/\lambda_m = 183075 - 2131{\cdot}414m + 12{\cdot}734m(m-1)/2$. Another series of doublets with a constant frequency difference of about 157 is represented well by a similar formula. Yet another series of doublets, excited by the mercury 5769·6 line has a frequency difference of about 2065. The series excited by the mercury 5790·7 line shows irregularities, the frequency difference between the components varying from 34 to 168. The spacing of the series along the spectrum is, however, more irregular. [See Abs. 227 (1914), 65 and 66 (1918) and preceding Abs.] A. W.

377. *Thermodynamics of Fluorescence.* **E. H. Kennard.** (Phys. Rev. 11. pp. 29–38, Jan., 1918.)—By applying thermodynamics to fluorescent substances a relationship is deduced between the coefficient of fluorescence and the intensity of black-body radiation. Assuming that fluorescence and thermal radiation are thermodynamically independent, and that the energy of fluorescence is derived from that of the exciting light, it is concluded that in the case of an isolated unitary band $\zeta = k\phi J$, where ζ = relative intensity in the fluorescence spectrum, ϕ = exciting power, and J = intensity in the black-

body spectrum for the temperature of the substance, all being taken for the same wave-length; and this equation appears to be confirmed by observed data. [See Abs. 988 (1918).] A. W.

378. *Resonance and Ionisation Potentials for Cd, Zn, and K Vapours.* **J. T. Tate** and **P. D. Foote.** (Nat. Acad. Sci., Proc. 4. pp. 9–10, Jan., 1918. Paper read before the Am. Phys. Soc., Dec. 1, 1917.)—Describes an experimental determination of the resonance and ionisation potentials for electrons in Cd, Zn, and K vapours. The method employed was that described by Tate for the determination of critical potentials in Hg vapour, and the apparatus was similar to that previously used by the authors in their work on Na vapour. The results obtained are shown in the following table, which also gives, for the sake of completeness, the results for Na vapour:—

Metal.	Resonance Potential (volts).		Wave-length of Radiation. Å.U.	Ionisation Potential (volts).		Limiting Wave-length of Series. Å.U.
	Observed.	Calculated.		Observed.	Calculated.	
Cadmium ...	3·88	3·79	3260·17	8·92	8·97	1378·69
Zinc	4·10	4·02	3075·99	9·50	9·37	1319·95
Potassium ...	1·55	1·65	7685·0	4·10	4·33	2856·0
Sodium	2·12	2·10	5893·0	5·13	5·13	2413·0

The curves for Zn vapour indicate the possible presence of a secondary inelastic encounter, apparently without ionisation, at 2·3 volts. Further work is in progress to make sure of this point. In all cases the results agree within the limits of experimental error with the values as calculated from the quantum relation. It is to be expected that the frequencies corresponding to the ionisation potentials should be the long wave-length limit of the photo-sensibility of the vapour in question. Experiments are now in progress to determine whether or not this is so. Concerning the question of the cause for the appearance of ionisation in metallic vapours at applied potentials much lower than the ionisation potential, it should be remarked that in no case was there an observable decrease in the value of the resonance potential even under conditions which permit of the appearance of the complete spectrum at low potentials. It is therefore thought that this setting in of ionisation at applied potentials much lower than the ionisation potential, is due rather to the presence of electrons having high initial velocities than to a decrease in the value of the critical potentials. The curves obtained with potassium vapour clearly show the presence of a large number of electrons having initial velocities corresponding to 1·6 volts. [See Abs. 68 (1918).]

A. W.

379. *Kathodo-fluorescence of Crystals.* **T. B. Brown.** (Phys. Rev. 11. pp. 39–57, Jan., 1918.)—The first part of this paper describes a quantitative investigation of the kathodo-fluorescence of willemite, kunzite, and soda glass by the late J. A. Veazey, and the second part deals with a further investigation of willemite by the author. Veazey's experiments show that for potentials not too small, the constant potential curves obtained for willemite and kunzite show a direct proportionality between the intensity of fluorescence and the kathode-ray current, and so far verify Lenard's relation $L = CI(V - V_0)$. The single curve for glass agrees approximately. If precautions are taken to prevent loss of charge by reflection, the curves obtained for willemite and kunzite for small discharge potentials likewise show this proportionality; except that, for the same potential, a much steeper line is obtained in a freshly exhausted tube than is obtained after the vacuum has been maintained at a low gas pressure, and discharge passed at a high potential, for some time previously. The constant-current curves for willemite, kunzite, glass, and heat-treated kunzite, do not agree with the Lenard formula, although they come closer to it than do the results of Leithäuser. The constant-current curves for willemite and native kunzite show marked hysteresis effects, while the glass and colourless (heat-treated) kunzite do not. The irregularities of the constant-current curves may be due to the effect of changes of temperature upon the fluorescent power of the crystal, or to changes of the reflecting power of the crystal, with changes of temperature. Some means must be provided to ensure that these conditions are constant before the exact relation between the intensity of fluorescence and discharge potential can be found. In Brown's work on willemite, the powdered crystals were heated to almost white heat. This had the effect of eliminating all hysteresis effects, though leaving the fluorescent properties unchanged. At constant potentials the relation between the intensity of fluorescence (L) and the discharge current (I) was in all cases a linear one, but the relation between L/I and V is certainly not a linear one. The results are not in agreement with the conclusions of Lenard, *i.e.* that the relation would be a linear one with a minimum potential existing below which no fluorescence could occur, but seem to be in good agreement with his data. As low down as the fluorescence could be observed the curve bends nearer and nearer towards the horizontal.

Further work on the subject is in progress. A. W.

380. *New Method of X-ray Crystal Analysis.* **A. W. Hull.** (Phys. Rev. 10. pp. 661–696, Dec., 1917.)—A brief description of this method was given before the American Physical Society in Oct., 1916 [*ibid.* p. 85, Jan., 1917). The methods of crystal analysis that have been developed by Laue and the Braggs are applicable only to individual crystals of appreciable size, reasonably free from twinning and distortion and sufficiently developed to allow of the determination of the direction of their axes. For the majority of substances, especially the elementary ones, such crystals cannot be found in nature or in ordinary technical products, and their growth is difficult. The method which the author now describes is a modification of the Bragg method, and is applicable to *all* crystalline substances. The quantity of material required is preferably 0·005 cm.^{3}, but 1/10 of this amount is sufficient. Extreme purity of material is not required, and a large admixture (uncombined) of foreign material, 20 or even 50 %, is allowable, provided it is amorphous or of known crystalline structure.

The method consists in passing a narrow beam of monochromatic X-rays *through a disordered mass of small crystals* of the substance to be investigated, and photographing the diffraction pattern produced. *Disorder, as regards orientation of the small crystals, is essential.* It is attained by reducing the substance to as finely divided a form as is practicable, placing it in a thin-walled tube of glass or other amorphous material and keeping it in continuous rotation during the exposure. Thus it is assured that the average orientation of the crystalline particles is a random one. It is easily seen that the diffraction pattern will contain reflections from every possible plane in the crystal or as many of these as fall within the limits of the photographic plate.

The theory of the method is given, and the tabulated results of a large series of observations on a variety of crystals are included in the paper. Excellent reproductions of photographs are shown in the following cases: Al, Fe, Si steel, Si, Mg, graphite, and diamond.

[*Note by Abstractor.*—Debye and Scherrer [Abs. 1130 (1916)] have described a method of crystal analysis which is essentially the same as that given above by Hull. The latter, however, makes no reference to the work of Debye and Scherrer, and has evidently discovered this novel method independently.]

A. B. W.

381. *Crystal Structure of Aluminium.* **P. Scherrer.** (Phys. Zeits. 19. pp. 23–27, Jan. 15, 1918.)—The method employed in this investigation is that developed by Debye and Scherrer [Abs. 1130 (1916) in which the structure of pulverised substances, "crystalline" or "amorphous," is analysed by means of X-rays. A similar examination of powdered pure Al (size of grains being less than 0·01 mm.) indicates that this element crystallises in the cubic system. The Al atoms are arranged in a simple face-centred lattice. The length of the side of an elementary cube is found to be $a = 4{\cdot}07 \times 10^{-8}$ cm. X-ray measurements of the structure of Cu, Ag, Au, and Pb by other observers have shown that these metals also crystallise as a simple cubic face-centred lattice. For these elements the following values are found for a:—

Cu .... $a = 3{\cdot}61 \times 10^{-8}$ Au .... $a = 4{\cdot}07 \times 10^{-8}$
Ag .... $a = 4{\cdot}06 \times 10^{-8}$ Pb .... $a = 4{\cdot}91 \times 10^{-8}$

All 5 elements are also (in the general sense of the word) amorphous.

A. B. W.

382. *Mathematical Evaluation of the Debye-Scherrer X-ray Spectrogram.* **A. Johnsen** and **O. Toeplitz.** (Phys. Zeits. 19. pp. 47–55, Feb. 1, 1918.)—A mathematical paper dealing with the Bragg and Debye-Sherrer methods of X-ray spectrometry. Comparisons between "experimental" and "calculated" reflection angles for a variety of crystals show good agreement. A. B. W.

RADIO-ACTIVITY.

383. *Nomenclature of Radio-elements.* **S. Meyer** and **E. v. Schweidler.** (Phys. Zeits. 19. pp. 30–32, Jan. 15, 1918.)—Proposals for a universal system of nomenclature for the radio-active families of radium, actinium, and thorium. The three series are denoted as follows:—

$$\begin{tikzcd}
\mathrm{U_I} \arrow[r] & \mathrm{UX_1} \arrow[r] & \mathrm{UX_2} \arrow[r] & \mathrm{U_{II}} \arrow[r] & \mathrm{Io} \arrow[r] & \mathrm{Ra} \arrow[r] & \mathrm{RaEm} \arrow[r] & \mathrm{RaA} \arrow[r] & \mathrm{RaB} \arrow[r] & {} \\
 & & & & & \mathrm{RaC''} \arrow[r] & {} & & & \\
 & & & & \mathrm{RaC} \arrow[ur] \arrow[dr] & & & & & \\
 & & & & & \mathrm{RaC'} \arrow[r] & \mathrm{RaD} \arrow[r] & \mathrm{RaE} \arrow[r] & \mathrm{RaF} \arrow[r] & \mathrm{RaG}
\end{tikzcd}$$

$$\begin{tikzcd}
\mathrm{Ac} \arrow[r] & \mathrm{RdAc} \arrow[r] & \mathrm{AcX} \arrow[r] & \mathrm{AcEm} \arrow[r] & \mathrm{AcA} \arrow[r] & \mathrm{AcB} \arrow[r] & {} & & \\
 & & & & & & & \mathrm{AcC''} \arrow[r] & \mathrm{AcD} \\
 & & & & & & \mathrm{AcC} \arrow[ur] \arrow[dr] & & \\
 & & & & & & & \mathrm{AcC'} \arrow[r] & {}
\end{tikzcd}$$

$$\begin{tikzcd}
\mathrm{Th} \arrow[r] & \mathrm{MsTh_1} \arrow[r] & \mathrm{MsTh_2} \arrow[r] & \mathrm{RdTh} \arrow[r] & \mathrm{ThX} \arrow[r] & \mathrm{ThEm} \arrow[r] & \mathrm{ThA} \arrow[r] & {} \\
 & & & & & & \mathrm{ThC''} \arrow[r] & {} \\
 & & & & \mathrm{ThB} \arrow[r] & \mathrm{ThC} \arrow[ur] \arrow[dr] & & \\
 & & & & & & \mathrm{ThC'} \arrow[r] & \mathrm{ThD}
\end{tikzcd}$$

In this system—

Isotopes are denoted by roman indices, as $\mathrm{U_I}$ $\mathrm{U_{II}}$
Successive Products are denoted by arabic indices, as $\mathrm{UX_1}$ $\mathrm{UX_2}$
Double Products are denoted by dashes, as C′ C″

A. B. W.

HEAT.

384. *Mechanical Equivalent of Heat.* **T. C. Sutton.** (Phil. Mag. 35. pp. 27–29, Jan., 1918.)—By a comparison of the author's direct determination of the heat of vaporisation of water at 100° C. [see Abs. 401 (1917)] with that obtained by Henning at the Reichsanstalt by the electrical method, the mechanical equivalent of heat is found to be $4{\cdot}185 \pm 0{\cdot}002$ joules per mean calorie. J. W. T. W.

385. *Vapour Pressure.* **P. E. Brunelli.** (N. Cimento, 14. pp. 55–68, Aug.–Sept., 1917.)—For water-vapour the author proposes the formula $\log_{10}p = 23{\cdot}08647 - 4{\cdot}5 \log_{10} T - (2980{\cdot}46/T) - 0{\cdot}00278\,T + 0{\cdot}000002825T^2$, where p is in mm. of mercury, $T = 273{\cdot}09 + \theta$° C. Comparison of this with other formulæ and with recorded data shows that this formula works extremely well. Application is made, with adjusted coefficients, to CO_2 and NH_3. A. D.

386. *A Criticism of Wien's Distribution Law.* **F. E. Wood.** (Phil. Mag. 35. pp. 190–208, Feb., 1918.)—The purpose of this paper is to criticise Wien's distribution law from a mathematical point of view: to show (1) that although the derivation of the latter is generally made by steps which are not mathematically justified, or for which no vigorous justification is given, still, by using Wien's assumptions, a rigorous derivation is possible; (2) that the law obtained by Wien is inconsistent with other results which follow from the same assumptions; and (3) that this inconsistency is eliminated and a new law obtained if Wien's implicit assumption be replaced by a simpler and more probable one. Several new theorems in the kinetic theory of gases are obtained from the Maxwell law for the distribution, with respect to the velocities, of the gas molecules; a simple proof of the Wien displacement law is derived from these theorems and the Wien assumptions, and two interesting relations regarding the dependence of the radiation of a molecule upon its velocity are given. There are also criticisms of the treatment of the distribution and displacement laws as given in standard treatises. Previously Mendenhall and Saunders, Waidner and Burgess, Rayleigh, etc., have criticised Wien's assumptions from a physical standpoint, while Lummer and Pringsheim, Paschen, etc., have considered the agreement of the distribution law with experimental results; no mathematical treatment has, up to the present, however, been published. The auxiliary theorems obtained from Maxwell's law are: (I) The number of molecules in a gas at temperature θ_1 which have velocities in a given interval is equal to the number of molecules of this gas at temperature θ_2 having velocities in the corresponding velocity interval. (II) The molecules having velocities in a given interval for $\theta = \theta_1$, will have their new velocities in the corresponding velocity interval for $\theta = \theta_2$. If the given velocity interval be taken sufficiently small then (III) the velocities v_1 and v_2 of a molecule of a gas at temperatures θ_1 and θ_2 respectively, satisfy the relation $v_1/v_2 = \sqrt{\theta_1}/\sqrt{\theta_2}$. (IV) The length of the waves produced by a molecule in a gas at temperature θ varies inversely as the square of the velocity, that is, $v^2 = b/\lambda$, where b is a constant and λ the wave-length. The ratio of corresponding radiation elements is found to be a function of θ_1 and θ_2 respectively; in particular this ratio does not depend upon the value of λ about which one element is chosen. Also, the intensity of radiation given off by a molecule varies directly as the eighth power of its velocity. H. H. Ho.

387. *The Necessary Physical Assumptions underlying a Proof of the Planck Radiation Law.* **F. R. v. Bichowsky.** (Phys. Rev. 11. pp. 58–69, Jan., 1918.)—To prove the Planck radiation law it is usually considered necessary to assume some sort of quanta, *i.e.* that some at least of the quantities connected with the distribution of energy in the spectra of a black body have physical significance only for the values E, 2E, 3E, etc., all intermediate values, say ½E, being impossible. There is, however, considerable disagreement as to just what the quantities are which thus occur in quanta. Einstein assumes radiant energy itself to be atomic in structure, Planck that matter (oscillators) is such that it can only give out energy in quanta, while Larmor [see Abs. 779 (1909)] makes the physically somewhat indefinite assumption, of equal regions of probability. Although Jeans [see Abs. 332 and 1407 (1906)] and Poincaré have undertaken to prove that quanta of some sort are necessary for a proof of Planck's law, yet their proof, and indeed all possible proofs, connecting the quantum hypothesis with the Planck law are vitiated by the fact that they all make a far more dubious assumption than the one they attempt to justify; since they assume, as it can be proved they must assume, that the radiating system has the statistical properties of a perfect gas. Once acceptance is made of both Planck's law and the quantum hypothesis, Maxwell's distribution law (which may be considered the definition of the statistical properties of a perfect gas) is shown in the paper to follow directly. Instead, therefore, of the quantum theory being a necessary consequence of the Planck law, we cannot prove the latter from the single assumption of the quantum hypothesis, but must necessarily make the further and arbitrary assumption that Maxwell's law holds for the local distribution of values of those coordinates fixing the distribution of radiant energy in a black body at steady state. The three laws therefore are not independent, the assumption of any two involving the third. Most of the criticism of the Planck equation has had to do, not with the Maxwell's law assumption, but with the quantum hypothesis. In the present author's opinion this has simply confused the issue, as the really doubtful part of the present derivation of the Planck law is the assumption that Maxwell's law holds, and it is the latter as applied to the case of a radiating system, not the assumption of quanta, that contradicts classical mechanics. The author's objection to the Planck law is that the kind of system assumed is not a proper kind of system, and he points out that if energy comes in a continuous stream and goes out in quanta there must be, between periods of discharge, a heaping up of energy. Thus it is necessary to assume some sort of reserved or bound energy different from the free energy of radiation, which Maxwell's law does not allow, as the author goes on to prove. Due to lack of experimental data with respect to the mechanism of radiation transfer, it is not possible to give an absolute solution to the problem, but the author quotes a function of Gibbs which points to continuous radiation being impossible until the ankylosed coordinates reach a certain value. Ratnowsky's paper on "The Entropy Equation of Solid Bodies and Gases and the Universal Quantum of Activity" is given as an appendix in the paper, since he by making Gibbs's assumption has shown that the Planck radiation law follows directly, and this without the assumption of quanta or discontinuities, without necessitating the giving up of infinitesimal analysis, without contradicting classical mechanics or the very cogent experimental evidence

of Duane and others showing quanta to have no physical existence, and with the very great advantage that the one physical assumption made, namely, that radiation is given off only when the energy of the system has become greater than a given threshold value and from there on is given off continuously, is of itself very probable. H. H. Ho.

388. *On the most probable Distribution to be employed for the Proof of the Boltzmann Principle.* **A. Smekal.** (Phys. Zeits. 19. pp. 7–10, Jan. 1, 1918.)—The new statistical thermodynamics has recognised the utility of the Boltzmann entropy-probability relation, $S = k \log w$, by accepting it without expressly inquiring whether it can be established solely on the basis of assumptions made in the respective cases considered. The present author here investigates the general conditions necessary in order that the above equation may be valid, his problem being stated as: "The circumstances requisite for the probability w to be an adiabatic invariant." The paper is mathematical throughout. H. H. Ho.

389. *The Equation of State of an Associating Substance.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 20. 3. pp. 365–381, 1918. Supplement No. 42A to the Comm. from the Phys. Lab. Leiden.)—Kohnstamm and Ornstein have pointed out that van der Waals' equation of state is not consistent with Nernst's thermodynamical theorem. Taking this theorem in the form which Planck has given it, namely, the entropy of a system in a condensed state at the absolute zero under its own vapour-pressure, *i.e.* under zero pressure, is zero [see Abs. 520 (1917)], which means that the entropy-difference between this condition and any other (excepting the ideal gas-condition) is finite, the contradiction consists in the equation of state of van der Waals giving for $v = b$ (the limiting volume) a value of the entropy which is lower than that for any other volume by an infinite amount. This objection only applies, however, to the equation in its original form, *i.e.* with a, b, and R constant; for it is evident that it must be possible by making these quantities change in a suitable manner to bring about not only a qualitative, but even a complete quantitative agreement between the equation of state and observation, and thus also with Nernst's theorem, if the latter is really in accordance with the experimental system of isothermals. The author shows that agreement with Nernst's theorem can be obtained by making R approach zero at the same time as T in an appropriate manner. A variation of R of that nature for a definite amount of substance means that the molecules combine to aggregates (association) or undergo a different process which resembles the former very closely (quasi-association), and which was repeatedly assumed by van der Waals and his pupils for the purpose of explaining the incomplete numerical correspondence between the original equation of state and the actual course of the isothermal. It was, however, always assumed that only one kind of molecular aggregate was formed, whereas for R to fall to zero a much more complex association (or quasi-association) is required, namely, a process in which the molecular groups formed become more and more complex, according as the temperature falls, until finally at $T = 0$ the substance behaves as if consisting of only one molecule, at least at small volumes. On this ground the author has attempted to extend the theory of association by introducing the hypothesis, that instead of one special aggregate all possible molecular complexes are formed: double molecules, triple, quadruple, etc. The method employed is on the lines followed by van der Waals in his theory of "quasi-association or molecular-aggregation," and the equation of state

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

395. *Electronic Charges.* **I[rene] Parankiewicz.** (Akad. Wiss. Wien, Ber. 1917. Ann d. Physik, 53. 15. pp. 551–568, Jan. 24, 1918.)—A detailed discussion of the experiments and their interpretations which lead some investigators to believe the smallest charge to be $4{\cdot}7 \times 10^{-10}$ e.s. unit and others to believe that still smaller charges actually occur. The present paper describes experiments on oil droplets rising in an electric field, and these are interpreted as supporting the view that charges occur much smaller than the ordinarily accepted electronic charge. [See Abs. 509 (1914).] E. H. B.

396. *Mechanical Theories of the Electromagnetic Field.* VI. **A. Korn.** (Phys. Zeits. 19. pp. 10–13, Jan. 1, 1918.)—This paper, the sixth contribution to the above subject, deals with electro-mechanical forces in slowly changing fields [see also Abs. 88 (1918)]. The mechanical forces previously considered were those exercised solely upon electrical particles and transmitted to ponderable particles. It is assumed that in every substance there are ponderable particles, in addition to electrical corpuscles, whose visible velocities agree with the average values of those of the electrical particles. In conductors, however, there may also be forces upon the electrical particles of such a character as to vary for positive and negative particles; only the average values of these forces are to be designated as mechanical forces. In consequence the negative particles will move in a different manner to the positive, thereby producing an electric current; it is in this sense that the author speaks of electro-mechanical forces. The theory of Universal Oscillations is introduced for the explanation of the above phenomena, and applied to the calculation of the electro-mechanical forces due to the field and their alteration in a slowly changing field. The author next applies his method to give a mechanical interpretation of the magnet; he accepts the Ampère standpoint and treats the magnetic particles as small current-elements. The discussion, however, is only general, the quantitative relations being reserved for a later communication. The assumption is made that the oscillations of the permanent magnetic particles have as their cause the pulsations of universal gravitation, and the magnetic theory sketched is based on this view. When the fundamental principles of the friction theory have been established [to be given later], the author states himself to be in a position to calculate the electric currents in conductors from the electro-mechanical forces.

H. H. Ho.

397. *Scattering of α-Particles as Evidence on the Parson Magneton Hypothesis.* **D. L. Webster.** (Am. Chem. Soc., J. 40. pp. 375–379, Feb., 1918. Chem. News, 117. pp. 175–176, April 26, 1918.)—The author attempts to show that the magneton hypothesis of Parson [Abs. 154 (1916)] is not an assumption made *a priori*, but is a most probable deduction from experimental facts. As such it cannot be lightly dismissed, even if the assumptions that go with it are somewhat complex. Consequently the author considers it probable that the α-ray phenomena should not be taken as valid evidence against the magneton theory, but simply as evidence for the existence of the nucleus along with its non-electrical repulsion for magnetons.

A. B. W.

398. *The Magneton as a Function of the Planck Constant.* **T. Wereide.** (Ann. d. Physik, 53. 15. p. 574, Jan. 24, 1918.)—The author here supplements his previous communication [see Abs. 678 (1917)] respecting the relation evolved between the magneton and Planck's constant. This relation is not based on numerical computation which gives for the zero point orbit of the electron very nearly 5 magnetons. According to this calculation, it may be asserted that an exact connection between the two physical magnitudes has not been attained. The primary feature of the earlier communication was the deduction of a formula showing that the quantity factor τ' is a whole number. The author now points out that the numerical calculation, although made by many previous investigators, has not been attended by any hint that a deduction of the relation was possible. The latter has been made by the identification of the magnetism of the electrons (moving in Bohr orbits) with that of the magneton theory. H. H. Ho.

399. *The Coefficients of Potential of Two Conducting Spheres.* **A. Anderson.** (Phil. Mag. 35. pp. 286–291, March, 1918.)—A direct method of determining the coefficients of potential of two conducting spheres is given, which obviates the necessity of calculating first the coefficients of capacity and induction. In proving the formulæ use is made of the following novel theorem in electrostatics: If a conducting sphere whose radius is a has a charge Q, and if other charged bodies be brought into the field, the potential V of the charge Q at an external point P whose distance from the centre of the sphere is r is given by $rV = Q + a(V_1 - V_2)$, where V_1 is the potential at the centre of the sphere of the introduced charges and V_2 their potential at P′, the inverse point of P in the sphere. Let A and B be the centres of the two spheres whose radii are a and b, the distance AB being c. Let I_1 be the inverse point of A in the sphere B, I_2 the inverse of I_1 in A, I_3 the inverse of I_2 in B, and so on. Similarly let J_1 be the inverse of B in the sphere A, J_2 the inverse of J_1 in B, etc. Then it is shown that if q_{11} be the coefficient of capacity of the sphere A and q_{12} the coefficient of induction between the two spheres, we have—

$$q_{11} = a + \frac{a^2b}{c}\left\{ + \frac{1}{AI_1} + \frac{ab}{AI_1 \,.\, BI_2 \,.\, AI_3} + \frac{a^2b^2}{AI_1 \,.\, BI_2 \,.\, AI_3 \,.\, BI_4 \,.\, AI_5} + \cdots\right\}$$

$$-q_{12} = \frac{ab}{c}\left\{1 + \frac{ab}{AI_1 \,.\, BI_2} + \frac{a^2b^2}{AI_1 \,.\, BI_2 \,.\, AI_3 \,.\, BI_4} + \cdots\right\}.$$

These equations can be shown to be the same as Clerk Maxwell's. A. R.

DISCHARGE AND OSCILLATIONS.

400. *The Striated Positive Glow Discharge.* **P. Neubert.** (Ann. d. Physik, 53. 14. pp. 492–496, Jan. 15, 1918.)—A discussion of the causes to which can be ascribed the positive striation in the glow discharge, based chiefly upon the results obtained previously by the author and by J. Stark. It is suggested that an exact examination of the spectrum along its whole range under simultaneous potential measurements at the striation and measurement of the general course of the potential, as well as more exact consideration of possible pollution through electronegative gas, may bring interesting disclosures and further enlightenment on the problem of striations. A. E. G.

401. *Conduction of Electricity in High Vacua.* **J. E. Lilienfeld.** (Sächs. Gesell. Wiss. Leipzig, Ber. 69. 1917. Elektrot. u. Maschinenbau, 35. p. 618,

Dec. 28, 1917. Abstract.)—The generation of X-rays in a Lilienfeld tube differs from that of the ordinary X-ray tube in that the green fluorescence of the glass walls does not appear. Lilienfeld tries to explain this difference in the action of the two types of tubes. He assumes that the secondary electrons which start from the antikathode of the new tube are in some manner deflected back to it, and so do not as a rule come in contact with the tube walls. He points out that the usual glass fluorescence does actually take place, but only in a ring of very restricted area behind the antikathode. A further object of the research is to ascertain whether there is actually a very steep potential gradient in the neighbourhood of the antikathode and if so what is its nature. The author, in order to explain the potential gradient, postulates an electric double layer, and the presence of this double layer is further assumed to influence the polarisation of the X-rays. A. E. G.

402. *Pressure Effect in Corona Discharge.* **A. M. Tyndall** and **[Miss] N. S. Searle.** (Phil. Mag. 35. pp. 261–269, March, 1918.)—When a glow discharge starts beween a cylinder and an axial wire, in a closed tube at atmospheric pressure, a sudden rise of pressure is observed. It has been argued by some that this cannot be due to heat generated in the discharge, and an alternative theory, that it is due to ionisation, has been advanced. In the present paper the authors criticise the argument for the ionisation theory, and the interpretation of the experimental results upon which it is based [Abs. 1166B (1914)]. Experiments are also described which verify quantitatively that the effect is purely thermal in origin. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

403. *Relation between Peltier and Volta Effects in Thermo-electricity.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 4. pp. 11–18, Jan., 1918.)—Considers the validity of the equation $P = T dv/dT$, in which P stands for the Peltier- and v for the Volta-effect between two metals. The author gives reasons for concluding that the failure of experiment to verify this equation is not entirely due to the difficulty of the experimental work, but that the equation neglects a reversible heating effect at the surface of a metal due to ionisation or recombination consequent upon the emission or reception of an electric charge by a metal. J. W. T. W.

404. *Dielectric Constants of Solids.* **R. Jaeger.** (Ann. d. Physik, 58. 14. pp. 409–460, Jan. 15, 1918. Abstract of Dissertation, Berlin.)—Describes research on the dielectric constants of a large number of solid substances, the measurements extending over a large range of wave-lengths ($\lambda = 10$ m. to $\lambda = 2 \times 10^6$ m.). The results obtained by the different methods employed are tabulated and compared. Kirchhoff's formula for the capacity of a plate condenser was subjected to experimental test in various ways, and was found to give good results for earth-capacities. It was also found that the method employed for determining the dielectric constants with the aid of a plate condenser gives, with careful measurements and calculations, very approximately correct results, which agree with those obtained by the method of separating the condenser plates. In the region of wave-lengths employed, no evidence was obtained of any electric dispersion in any of the substances dealt with. A. W.

405. *Thermal and Electrical Conductivities of Carbon Steels at High Temperatures.* **K. Honda** and **T. Simidu.** (Tohoku Univ., Sci. Reports, 6.

pp. 219–238, Nov., 1917.)—In a previous paper Simidu [Abs. 102 (1918)] has measured the thermal and electrical conductivities of some carbon steels at ordinary temperature. The Wiedemann-Franz law was shown to hold although the constant differed from the theoretical value. In the present paper, observations have been continued up to 900° C., and similar tests on Swedish iron and Ni have been made. To measure the thermal conductivity, the specimens were in the form of short cylinders 8 cm. long, 1 cm. thick. A small heating coil was placed in a cylindrical cavity, drilled in the centre of the specimen, and the rate of supply of heat Q was determined. The rod being lagged, the differences of temperature Δt_1 and Δt_2 between pairs of points at the same distance l apart, but on opposite sides of the source of heat, were measured. The thermal conductivity is then $Ql/S(\Delta t_1 + \Delta t_2)$, where S is the cross-sectional area. The whole was placed in a suitably designed electric furnace and raised to any desired temperature in an atmosphere of H. The electrical resistance was measured by a potentiometer method. Tables of results and curves are given in the paper. For Swedish iron, steel, and Ni, the thermal conductivity decreases, first slowly and then somewhat rapidly as the temperature increases. Above the A2 point it increases slightly and linearly with rise of temperature. The change is quite parallel with that of magnetisation. Angell has found a bend in the conductivity-temperature curve for Ni at 700° C., but the author's results do not show such an abnormal point. Up to the critical point the specific resistance of Swedish iron increases with rise of temperature, the resistance-temperature curve being slightly convex towards the axis of temperature. Above the critical temperature the relation is almost linear. If this line be produced backwards, then the difference of its ordinates and those of the observed curve at any temperature represents the diminution of resistance in virtue of the ferromagnetic state. From this point of view, the change of resistance due to temperature is parallel to that of magnetisation. The resistance-temperature curve for Ni is similar, the critical point indicated being 360° C. For the carbon steels, the range of the A1 transformation differs. With increasing C contact, the magnitude of the transformation increases up to about 0·9 % C, and then slowly decreases. During the A*c*1 transformation the resistance increases abruptly, and during the A*r*1 it decreases, the difference between A*c*1 and A*r*1 points amounting to some 60 deg. Above the A1 point the resistance increases linearly with the temperature.

The Wiedemann-Franz law holds fairly well for all temperatures. Theoretically, $k\sigma$ should be proportional to the absolute temperature. Except in the case of Swedish iron and two steels of small C content this relation is not satisfied, although in all cases the product $k\sigma$ varies linearly with the temperature. In the case of Ni, the departure from this law is probably accounted for by the presence of impurities. Analysis of the specimen showed only 96·8 % Ni. L. L.

406. *Optical Ammeter.* **P. D. Foote.** (Washington Acad. Sci., J. 8. pp. 77–82, Feb. 19, 1918.)—Suggests the use of a pyrometer lamp for the measurement of alternating current. The filament is matched against a diffusing screen illuminated by a standard lamp, and it is shown that if the photometric match is made with an accuracy of 0·5 %, the current passing through the pyrometer filament is determined to an accuracy of 0·08 %. The apparatus is described and illustrated in the paper. For the determination of a current of some pre-assigned value, the two lamps should have

widely differing temperature-current characteristics. The current in question is passed through them in series, and is raised until a match of brightness shows that the desired current value has been attained. For if the characteristic equations of the two lamps be $i = a + bt$ and $i' = a' + b't'$ then when $t = t'$ and $i = i'$ we have $i = (ab' - a'b)/(b' - b)$. J. W. T. W.

407. *A Thermoelectric Standard Cell.* **C. A. Hoxie.** (Am. I. E. E., Proc. 37. pp. 57–64, Feb., 1918.)—The principle of this secondary standard of e.m.f. or of current, is as follows: The p.d. across a resistance is balanced against the thermoelectric e.m.f. of a thermo-couple. This requires a definite value of the current through a filament which is the source of heat to the thermocouple. The thermal e.m.f. varies as the square of the current through the heating filament, while the drop across the balancing resistance, in series with the heating filament, varies directly as the current. Consequently, for one critical value of the current, the thermal e.m.f. equals the drop of potential across the balancing resistance.

The heating filament and thermo-couple are sealed in a glass bulb containing nitrogen at a pressure of about 2 cm.

It is stated that a properly constructed cell will remain constant to at least 5 parts in 10,000.

The temperature coefficient of the cell may be reduced to zero by choosing for the balancing resistance a wire having a temperature coefficient equal to the temperature coefficient of e.m.f. of the thermo-couple for a given difference in temperature between the cold and hot ends. E. G.

408. *Electrometer for Radio-active Investigations.* II. **[Miss] H. J. Folmer.** (K. Akad. Amsterdam, Proc. 20. 5. pp. 684–695, 1918.)—The ionisation chamber of the electrometer here described, consists of a brass cylinder of 1-litre capacity. Above this, and insulated from it by ebonite, is the electrometer proper. This consists of a shallow cylindrical brass box, which encloses two needles. One of these is supported by a Pt-wire passing through amberoid insulating plugs to the ionisation space. The second is of thin Al, and is supported by a Wollaston wire from a torsion head. A radial hole through the ebonite and amberoid insulation allows contact to be made with the Pt-wire carrying the fixed needle. The amberoid insulation is surrounded by a tubular guard-ring, which can be earthed or insulated as desired. Special arrangements permit a moderately high vacuum to be maintained in the ionisation chamber. Diagrams are given, together with a description of the method of operation under various conditions. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

409. *Suppression of Hysteresis in Iron-Carbon Alloys.* **C. W. Waggoner** and **H. M. Freeman.** (Gen. El. Rev. 21. pp. 143–145, Feb., 1918.)—A study of the effect caused by superimposing a longitudinal alternating magnetic field on a hysteresis cycle that is produced by a slowly varying direct-current field. The physical properties of the material under test have been already reported [Abs. Nos. 1617 (1909) and 1583 (1912)]. The samples of iron were 40 cm. long and 0·5 cm. in diam., and the hysteresis cycles, which were registered photographically, were all completed in 4 secs. for each specimen. The max. fields applied were 42·8 c.g.s. with direct current and 58·7 with alternating current. The impressed alternating field causes a suppression of the hysteresis which is a more or less direct function of the carbon content. Contrary

to expectation, this diminution in hysteresis cannot be likened to that obtained by mechanical vibrations, since the effect grows with the carbon content.
G. E. A.

410. *Theory of Hysteresis Loss by Magnetisation.* **K. Honda** and **J. Ôkubo.** (Tohoku Univ., Sci. Reports, 6. pp. 183–195, Nov., 1917. Tenth Report of the Alloys Research Inst.)—In a previous paper [Abs. 1287 (1916)] the authors have developed Ewing's theory of molecular magnetism quantitatively and have satisfactorily accounted for the well-known curves of magnetisation and hysteresis. The effect of temperature on magnetisation has also been explained [Abs. 257 (1917)]. In the present paper, starting from the point of view that the hysteresis loss is the kinetic energy obtained by the molecules during their abrupt rotations, the authors establish theoretically that in a cyclic process of magnetisation, the kinetic energy thus obtained is equivalent to the area enclosed by the hysteresis loop. It is assumed that, with the absence of external field, all the elementary magnets in each complex have the same direction for stable equilibrium, and, consequently, for weak magnetising fields, theory shows no hysteresis loss. But in actual cases the elementary magnets on the bounding surfaces of the complexes may place themselves in directions different from those in the interior. The application of a weak magnetising force may cause abrupt rotation of these, and hysteresis phenomena thus occur with weak fields. It is then shown how the loss for a given magnetising field may be calculated and the result is in agreement with the Steinmetz law. The theoretical deduction in the case of rotating fields conforms in character with the well-known experimental curves. Finally the hysteresis loss in magnetite is considered and the results obtained agree with the experimental conclusions of Quittner. L. L.

411. *Molecular Theory of Ferromagnetic Substances.* **K. Honda** and **J. Ôkubo.** (Phys. Rev. 10. pp. 705–742, Dec., 1917.)—An extension of a previous paper [see Abs. 1287 (1916)], containing sections on the calculation of hysteresis loss and on the effect of temperature on magnetisation. G. E. A.

412. *Internal Moment of Momentum in Iron and Nickel.* **J. Q. Stewart.** (Phys. Rev. 11. pp. 100–120, Feb., 1918.)—Describes an experimental verification of the momentum effect in iron and nickel predicted by Richardson in 1908 for magnetisable substances. Seventeen iron wires and six nickel wires were employed, and every wire showed the effect sought for; moreover, all the observations agree qualitatively, and show also good quantitative agreement. Special care was taken to eliminate disturbing effects, and it was found that this elimination was best accomplished if the residual magnetism of the wires was used in the experiments. It has usually been assumed in theoretical consideration of the Richardson-effect that only the motion of negative electrons within the atom is concerned. But this assumption leads to an internal moment of momentum twice that observed. The observed magnitude of this momentum can be accounted for if positive, as well as negative, charges are moving within the atom, but in opposite directions. The experimental results of Barnett [Abs. 1761 (1915)] and of Einstein and de Haas [Abs. 1128 (1915)] are in qualitative agreement with those here given. It should be possible, with the experimental method employed, to observe the Richardson-effect in cobalt and the Heusler alloys, and perhaps also in magnetite. [See Abs. 1266 (1916).] A. W.

413. *Magnetic Investigation of the States of Cementite in Annealed and Quenched Carbon Steels.* **K. Honda.** (Tohoku Univ., Sci. Reports, 6.

pp. 149–152, Sept., 1917.)—The intensity of magnetisation of a number of steels and a cast iron has been measured [see Abs. 1892 (1914), 692 (1917)] during the heating and cooling of specimens in both the annealed and hardened (quenched from 900° C.) conditions. In every case, starting from the annealed state the specimens clearly show the A0 transformation, indicating the cementite to be in the free state. On heating previously quenched specimens there is a gradual increase of magnetisation, showing that the dissolved cementite is set free. After heating to 260° C. the A0 transformation reappears, and increases in intensity as the temperature of heating is increased. It appears that the rejection of cementite from solution is mostly effected in the first 400 deg. C. After quenching from 1150° C. the cast iron showed no trace of the cementite change on the subsequent heating, showing all the cementite to be in solution. None was set free until the specimen had been reheated to 330° C. On cooling from 900° C. the A0 transformation was reduced to about ⅓ of its original magnitude, showing that much of the cementite had been decomposed into its constituent elements: ferrite and graphite. F. C. A. H. L.

414. *Magnetic Investigation of A3 and A4 Transformations in Pure Iron and Steels.* **T. Ishiwara.** (Tohoku Univ., Sci. Reports, 6. pp. 133–138, Sept., 1917. Seventh Report from the Alloys Research Inst.)—The work on the A1 transformation [Abs. 692 (1917)] has been extended to the A3 and A4 transformations by the method described in Abs. 241 (1916). With regard to the A3 transformation, it was found that 3 to 4 hours were required for the complete transformation, which occurred between 893° and 906° C. on heating and between 890° and 900° C. on cooling. These figures are so close that the change might almost be regarded as a reversible one. Comparing the results with those obtained by Honda and Takagi [Abs. 241 (1916)] close agreement exists in the values for the A*r*3 point, but more rapid cooling places the A*c*3 point about 10 deg. higher than the value obtained on very slow cooling. This indicates that the rate of change of temperature affects the transformation on cooling to a less degree than it does on heating.

The A4, or γ–δ, transformation has been placed at temperatures between 1210° and 1420° C. by various investigators, and it was not quite clear whether the change occurred at a definite temperature or over a certain temperature range. Experiments on pure iron and pure steels indicates that above 900° C. the susceptibility of γ-iron slowly diminishes until at 1395° C. there is a sudden rise from 26×10^{-6} to 37×10^{-6}, after which the value again decreases with increase of temperature. On cooling, the A*r*4 transformation takes place some 10 deg. lower. The following table sums up the work of the Tohoku laboratory on the transformations occurring in iron and mild steels, the changes marked X being confined to mild steels.

Transformation.		Temperature.	Nature.
X	A0	215° C.	Mag. transformation of Fe_3C.
X	A1	727°	Eutectoid transformation
	A2	800°–780°	Mag. transformation of Iron
	A3	908°	α–γ transformation
	A4	1390°	γ–δ transformation

While A1, A3, and A4 may properly be called changes of phase, A0 and A2 are not such changes in the true sense of the term. F. C. A. H. L.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

415. *A New Radiator Type of Hot-kathode Röntgen-ray Tube.* **W. D. Coolidge.** (Gen. El. Rev. 21. pp. 56–60, Jan., 1918.)—The type of tube described was developed specifically for military use in the portable X-ray outfits at the Front. Its characteristics are such, however, that it seems ultimately destined to supplant the earlier type of hot-kathode tube for all diagnostic work. A study of the situation had shown that the electrical efficiency of existing portable X-ray generating outfits was low, and that it could be very greatly increased if a suitable tube could be made for operating directly from the secondary of a high-tension transformer without the use of any auxiliary rectifying device. The earlier form of the hot-kathode tube having a solid tungsten target is capable of rectifying its own current, but only for such amounts of energy as do not heat the focal spot to a temperature approximating that of the kathode spiral. So soon, however, as any part of the focal spot is heated to a sufficiently high temperature, it emits electrons copiously, and therefore, when supplied from a source of alternating potential, it permits so-called "inverse" current to pass. The inverse kathode-ray stream comes out from the focal spot in a direction perpendicular to the face of the target and proceeds, in the form of a narrow pencil, straight to the glass wall of the bulb, close to and slightly behind the kathode. The glass at the spot fluoresces vigorously, becomes locally heated and cracks. The local heating of the glass, attendant upon overloading a tube which is running on alternating current, can be prevented by making the kathode focusing device of some refractory metal such as molybdenum or tungsten, and so locating this in the tube that it intercepts the "inverse" kathode-ray stream. While this method has proved exceedingly useful as a safety device when such a tube is to be used on alternating current, it does not appreciably increase its capacity, for it would obviously be undesirable to have the kathode focusing-device giving off X-rays under such bombardment. The essential condition to be fulfilled was that heat should be more rapidly withdrawn from the focal spot. Experiment showed that the most effective simple method consisted in providing a target having a large heat capacity and high heat conductivity, and then in arranging to cool this mass of metal effectively during the interval between radiographic exposures. It is very important that the target should be cold at the start of each exposure. These considerations finally led to the anode being designed as follows: The anode stem consists of a solid bar of Cu 1·6 cm. in diam. which is brought out through the glass of the anode arm to the copper radiator. The head of the anode consists of a mass of specially purified copper which is first cast in vacuum on to a tungsten button and is then electrically welded to the stem. The tungsten button, which is destined to receive the kathode-ray bombardment is 2·5 mm. thick and 9·5 mm. in diam. The complete target, with radiator, weighs 860 gm. and has a heat capacity of 81 cals. per 1 deg. C., while the present standard solid tungsten target, complete with molybdenum stem and iron supporting tube, has a heat capacity of less than 10 cals. Because of its greater heat capacity, it takes much longer to heat the radiator type of target to a given temperature than it does the solid tungsten target. What is much more important, however, is the fact that between radiographic exposures the target in the new tube cools comparatively rapidly owing to the larger copper stem and the radiator. In the new radiator type of tube by far the greatest part of the energy imparted to the target is conducted to the radiator. It, therefore, becomes possible to make the glass bulb very small. For portable work a diam. of 9·5 cm. has

been standardised. The exhausting of such a tube is a difficult task. It is found that in this tube the temperature of the focal spot can be raised to that of the kathode spiral and even brought to the melting-point, while the tube is operating on alternating current, without the tube allowing any appreciable "inverse" current to pass. It is suggested that this may probably be due to oxygen remaining in the tungsten target. A lead glass protective shield is described. The advantages which this new type of shield possesses over the earlier type for diagnostic work are the following:—(1) It can be used to rectify its own current under conditions of service which are severer than would be permissible with the earlier type of hot-kathode tube having the same size of focal spot. (2) The bulb can be smaller than is permissible with the earlier type handling the same amount of energy. (3) On alternating or rectified current it will carry the max. allowable energy for a much longer time. (4) It can have, even for heavy duty, a close-fitting tube-shield. A. E. G.

416. *Dosimeter in X-ray Therapy. Choice of the Best Radiation.* **H. Guilleminot.** (Comptes Rendus, 165. pp. 672–674, Nov. 12, 1917.)—This paper deals essentially with practical matters, in particular the choice of the most suitable radiations for different purposes. Two cases are considered in detail: (1) Superficial lesions, (2) Deep-seated lesions with healthy skin. In connection with the latter a table is given for efficacy 25 at the level of the Malpighian layers, (*a*) the dose corresponding to the various incident radiations and (*b*) the efficaceous doses acting at different depths under such conditions. The important question of the suitable filtration of the radiation so as not to injure superficial or more deep-seated tissues is briefly considered. [See also Abs. 307 (1918).] A. E. G.

417. *Ropiquet's Orthodiascope for Localisation of Projectiles.* (Archives d'Él. Médicale, 25. pp. 496–515, Nov., 1917.)—This apparatus has been called an orthodiascope, because by its means it is possible to mark upon the skin, the orthogonal projection of an internal organ or foreign substance situated in the body. It is not a novelty, since it has been in use since August, 1914, but a full account of its parts and of the method of using it is now given. A. E. G.

418. *Localisation of Projectiles. A Special Compass.* **Angebaud.** (Archives d'Él. Médicale, 25. pp. 537–549, Dec., 1917.)—The arrangements here described have been in use since 1914. The radiological table is of special construction although not unique: the arrangements in connection with the screen form the principal feature of this method. This part is dealt with in detail, as is also the method of using the apparatus. A special form of compass for use in localising projectiles is illustrated and the method of employing it described. A. E. G.

419. *The Nemirovsky Localising Compass.* **Mondain.** (Archives d'Él. Médicale, 26. pp. 9–17, Jan., 1918. Paper read before the Acad. de Médecine.)—This apparatus, which is based upon the method of localisation by double image on a non-graduated screen, is described in detail and its use thoroughly explained by means of a comprehensive series of diagrams. It is possible by its aid to make several localisations before operating; further, it secures the maximum protection to the face and hands of the radiographer.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

420. *A Silica-glass Mercury Still.* **J. C. Hostetter** and **R. B. Sosman.** (Washington Acad. Sci., J. 8. pp. 11–15, Jan. 4, 1918.)—The stills are for heating from the lamp circuit. Stills of ordinary glass and even of combustion glass had, at the Geophysical Laboratory, failed in several instances, because when the pressure in the mains went up a few volts, the glass had softened and collapsed; in one case the tube had not been flattened, but had yielded symmetrically all round, producing a figure with three cusps separated by angles of 120°. The still is a cup, 110 mm. high, 18 mm. diameter, placed at the top of a tube 720 mm. high, 8 mm. in diam. (5 mm. would be preferable), and surrounded by an alundum cylinder on which nichrome wire is wound; the cup is joined, through its bent neck, to the vertical condenser tube, 18 mm wide, which is connected below with another vertical tube, 840 mm. high, and above with a suction pump giving pressures of less than 1 cm. of mercury. All the parts are made of silica-glass, which must be transparent in the case of the high tubes so that the mercury level can be watched. The mercury should previously be purified, and this can be done after H. Leffman, by shaking it up with cane-sugar solution and filtering it through a pin-hole. H. B.

421. *The Convergence of the Liquid and Solid Volume Curves to Absolute Zero.* **G. Le Bas.** (Chem. News, 116. pp. 307–308, Dec. 28, 1917.)—The author shows that in the case of tin-lead alloy (Sn_2Pb), phosphorus (white), the higher paraffins, and, generally, the specific volume-temperature curves for the solid and liquid converge to absolute zero. As it has been shown that the specific heats of compounds vary in a similar manner to that of volumes, it may be possible, eventually, to compare the energy content of the atoms from absolute zero with the atomic volumes and possibly to find a law connecting the two. This would lead to an exact understanding of the kinetic conditions ruling in molecules. A. F.

422. *Notes on the Annealing of Glass.* **S. English** and **W. E. S. Turner.** (Chem. News, 117. pp. 58–59, Feb. 1, 1918. Paper read before the Soc. of Glass Technology, Jan. 16, 1918.)—Two kinds of glass were heated to remove strains; in one case the strains disappeared rapidly at 620° C., in the other at 460°. Annealing was completed, in one case, at 700° in 6½ hours, at 425° in 2½ hours, at 450° in 12 minutes. In these experiments expensive laboratory apparatus was used. In practice it is sufficient to watch the temperature, at which a rod of the glass, 4 ft. long, 7 mm. in diam., begins to bend rapidly without softening; the temperature observed is the suitable annealing temperature. Cooling curves of glasses in the lear were also discussed. H. B.

423. *Preparation of Pure Metals.* **F. Mylius.** (Zeits. f. Elektrochem. 23. pp. 152–153; Disc., 153–154, May 1, 1917. Zeits. Instrumentenk., Beib. 23. and 24. pp. 177–179, Dec. 15, 1917.)—The commercial terms "pure," "purissimum," etc., being objectionable, the author proposes to distinguish substances as of first, second . . . sixth grade, according as they contain 1 part of total impurity in 10, 10^2 . . . 10^6. In the case of water the six grades would be represented by water from the Ocean, the Baltic, wells, rain, distillation, and conductivity water. Analyses become very difficult with higher purity, and it may be advisable to extract impurities before the analyses or to

add them purposely for easier determination. Various ways of preparing "normalised" metals of the grades are mentioned; zinc, cadmium, and lead of the fourth grade (0·01 %) are being supplied by Kahlbaum on the instigation of the Reichsanstalt. H. B.

424. *Effect of the Presence of a Small Amount of Copper in Medium Carbon Steel.* **C. R. Hayward** and **A. B. Johnston.** (Am. Inst. Mining Eng., Bull. No. 133. pp. 159–167, Jan., 1918.)—The mechanical properties of two steels containing respectively C 0·38 %, P 0·012 %, Mn 0·57 %, S 0·030 % Cu 0·86 % and C 0·365 %, P 0·058 %, Mn 0·59 %, S 0·048 %, and Cu 0·030 %, have been compared in various heat-treated conditions. In all conditions the high-copper steel shows a marked superiority over the low-copper steel. The high-copper steels show higher values for the yield-point, ultimate stress and reduction of area, but a slightly lower value for the elongation, than the low-copper steel. Hardness tests by both the Brinell and Shore methods show the high-copper steel in all tests to be harder than the low-copper steels, while at the same time the former steel gives appreciably higher values under the Charpy impact test. Apparently the behaviour of Cu resembles that of Ni in steel. F. C. A. H. L.

425. *Note on the Microstructure of Commercially Pure Iron between Ar3 and Ar2.* **W. J. Brooke** and **F. F. Hunting.** (Iron and Steel Inst., J. 96, pp. 233–239; Disc. and Corres., 240–250, 1917. Engineering, 104. pp. 532–534, Nov. 6, 1917.)—The Shelton Iron, Steel and Coal Co., Ltd., have succeeded in producing a basic open-hearth steel, known as "Armco Iron," which has a guaranteed purity of 99·84 % Fe. However, the material shows a characteristic red-shortness when mechanically treated between 800° and 900° C., while outside these limits of temperature it possesses extraordinarily high ductility and malleability. The brittleness is much more marked on cooling than on heating. Tensile tests made on specimens quenched from various temperatures between 1040° and 575° showed no signs of brittleness, but specimens quenched between 800° and 900° C. gave crystalline fracture whilst outside this range the fractures are fibrous. Microstructures of the specimens quenched outside the range showed either γ or α structure, but in the zone between $Ar3$ and $Ar2$ a peculiar eutectoid structure appeared between the grains. The red-shortness is attributed to this constituent but confirmatory evidence has not yet been obtained. Swedish iron showed similar phenomena, but in an iron containing 0·06 % C, and 0·10 % Mn, the brittleness was lacking. Tentatively, the authors advance the explanation that iron of such relative purity possesses the property of rejecting from solution between $Ar3$ and $Ar2$ a eutectoid probably composed of carbide, phosphide, sulphide, and oxide of iron with, probably, manganese sulphide. The paper is illustrated by 14 micrographs.

F. C. A. H. L.

426. *Investigation upon a Cast of Acid Open-hearth Steel.* **T. D. Morgans** and **F. Rogers.** (Iron and Steel Inst., J. 96. pp. 209–218; Disc. and Corres., 219–231, 1917. Engineering, 104. pp. 355–357, Oct. 5, 1917.)—Gives full details of an investigation carried out with a view of determining the general quality and uniformity of a 40-ton charge of steel from an acid open-hearth furnace. The results include analyses of pit samples taken immediately before casting each ingot, analyses of the top, middle, and bottom billet from each ingot and tensile and Brinell hardness tests of the same, together with photomicrographs. C. O. B.

427. *Heat Treatment of Grey Cast Iron.* **J. E. Hurst.** (Iron and Steel Inst., J. 96, pp. 121–128; Disc. and Corres., 129–135, 1917. Engineering, 104. pp. 330–332; Disc., 324, Sept. 28, 1917.)—The behaviour of cast iron when subjected to heat, so far as it is concerned with the deterioration of liners, pistons, and valve chambers of cylinders, is dealt with. These cylinder components, which are subjected to the direct influence of heat, crack, and this cracking is most pronounced in the cast-iron piston heads of Diesel engines.

In the ordinary four-cycle gas engine the centre of the head reaches a temperature of 650° to 700° C., and the inner surface in the centre of the piston-head in a Diesel engine probably reaches 900° to 950° C.

A series of analyses are given of a cracked Diesel-engine cylinder; these show that the only change attributable to the heating is the conversion of the combined carbon into graphite carbon.

A series of analyses is also given to show the effect of heat treatment on the condition of the carbon in grey cast iron. The results given show that the effect of heating to 750° for two hours, followed by quenching in water, is to convert the whole of the combined carbon into the graphite state.

The microscopical structure of the iron from a cracked Diesel-engine piston is described and illustrated, and also that of grey cast iron before and after heat-treatment.

The author considers that the ultimate cracking of Diesel-engine piston tops (apart from the cases of mechanically defective pistons) can as a general rule be traced to the phosphorus content of the cast iron. C. O. B.

428. *Time Effect in Tempering Steel.* **A. E. Bellis.** (Am. Inst. Mining Eng., Bull. No. 134. pp. 331–333, Feb., 1918.)—Shows that the time effect in reheating certain steels below the critical range is very marked, and is most important when a max. drawing effect is desired, in which case the highest physical properties and ease of machining are important considerations. The following table shows some of the results obtained; the time required in the reheating for the work to come to temperature was not counted and was about 20 to 30 mins. The steel was of the following composition: C 0·54, S 0·05, Mn 1·22, P 0·065 %, and had been oil-quenched from 1500° F. The reheating was carried out at 1180° F.

	Oil-quenched.	Reheated for 30 mins.	Reheated for 2 hrs.
Elastic limit, lbs. per sq. in..........	69,800	117,450	116,800
Tensile strength, lbs. per sq. in....	128,700	132,500	131,750
Elongation, per cent.	15·0	16·0	20·0
Contraction, per cent.	35·2	42·1	51·0

C. O. B.

429. *The Erosion of Guns.* **H. M. Howe.** (Am. Inst. Mining Eng., Bull. No. 134. pp. 335–390, Feb., 1918.)—The paper deals with the hardening of the bore of guns due to its rapid cooling by the outer metal; the cumulative cracking of the bore, and the possible palliatives of erosion. The explanations of the various phenomena are based briefly on a hypothetical "temperature cycle," or course of heating and expansion in each round.

The conclusions are based largely on the results of examination of two rings cut from an eroded 14-in. gun liner containing C 0·38, Mn 0·655, Ni 2·81 %.

At any section the cycle begins with the passage of the driving band of the projectile, from which the lips of each crack hardened in the preceding round, cuts off some copper and seals itself. Next comes extremely rapid heating, expansion and closing of the cracks, with extrusion of much of the copper. A thin layer of the bore-face is melted and swept forward by the rush of the gases, the metal removed from any one section being replaced in part by that swept forward from rear sections, keeping all cracks sealed till the bore-face metal again hardens. With this probably goes the entrainment of some of the molten metal as a mist, its bodily removal from the gun, and choke-boring.

In the heating period some of the initially distinct particles of ferrite and cementite adjoining the bore-face form austenite. The following cooling by conduction into the cold outer metal is so rapid that this austenite is caught in the state of martensite and is thus hardened. It is next annealed during the heating period of the next round, and in part eroded and rehardened in the following cooling. The thickness of the hardened layer increases from round to round. There appears to be no carburisation of the bore-face by the powder gases.

The hardening may hasten erosion by causing particles to flake off from the bore-face, while it is heating up.

Cracks are caused by the fact during the cooling of each round the layer which has been fluid or, at least, pasty, cools, and hence contracts much more than the outer and cooler layer with which it is integrally united, and thus becomes stretched beyond its ability to retain continuity. The copper stopping of each crack and the oxidation of its sides during the period of contraction cause the cracking to be cumulative, so the total width of the cracks is about 10 times that corresponding to the contraction occurring in a single round.

The cracking of the bore probably neither hastens erosion nor weakens the gun.

The temperature of the metal eroded probably rises to the solidus if not to the liquidus, but some of the metal eroded is probably between the solidus and a lower temperature—that of erodible mobility. Volatilisation probably does not contribute greatly to erosion.

White-hardness and also great thermal conductivity, specific heat, and density, should lessen erosion. Suggested methods of lessening erosion are:—(1) To reduce the temperature by devising an explosive which will deliver more of its energy as pressure and less as heat. (2) By lubrication—for example, with graphite. (3) By devising ready means of drawing and replacing the gun liner. This seems the most promising means. (4) By using a less erodible metal. Though experiments with other alloys of high melting-point should be tried the prospect of success is not great, because the available metals less fusible than iron yield metals more fusible than it is itself, and which are difficult to machine, costly, and prone to oxidise.

The success of manganese steel in pipe balls, in resisting conditions closely like those of gun liners, suggests the advisability of experimenting with it. C. O. B.

430. *Thermoelectric Properties as a Method of Analysis for Mixed Crystal Alloys.* **G. Borelius.** (Ann. d. Physik, 53. 16, pp. 615–628, Feb. 1, 1918.)—Among alloys of Au, Ag, Cu; Pt, Pd, Ni; Ir, Rh, Co; Fe and Mn are series with mixed crystal formation, and investigations by various observers have shown that the thermal and electrical conductivities in their dependence

upon concentration are represented by catenary curves. A similar law has been proposed for the thermoelectric properties of such alloys. The present author has measured the Peltier-effect against copper, of alloys of Pd-Ag, Pd-Au, and Pd-Pt, and is led to the conclusion that the catenary law does not hold. The thermoelectric force, for these same alloys, has previously been measured by Geibel, and some of the results are included in the paper, supporting the author in the following conclusions :—(1) In the series of alloys investigated, forming mixed crystals, the curve showing the dependence of both Peltier heat and thermoelectric force on atomic concentration is made up of straight line portions. (2) The intersection of these straight lines always corresponds to a simple percentage of the constituents. Further evidence, conforming to this view, is also obtained from data available by other observers on Ni-Cu alloys. The linear variation of the Peltier heat with atomic concentration would present a difficulty to the ordinary electron theory, since it would require the electronic concentration to vary exponentially. L. L.

431. *Note on the System of recording rate of Chemical Reaction.* **J. W. McBain.** (Faraday Soc., Trans. 13. pp. 1–2, Dec., 1917.)—Equations representing rate of reaction may be written in the form $k = 1/t$ (remainder of the expression). In this note the author proposes to set k always equal to unity and to choose the unit of time accordingly. The equation then simplifies to $t =$ (remainder of expression). In this way we avoid the use of small decimals and the "unit of time" gives a direct idea of the rate of reaction. Thus $t = 63$ mins. means that if the concentration is kept at unity it will take 63 mins. for 1 gm.-mol. of the substance to react. In the case of monomolecular reactions the new "unit of time" gives the time required for the reaction to go to the extent of 63·2 %. Further, if multiplied by the natural logarithm of 2 (viz. 0·693), it gives the time required for the reaction to go half-way. A. F.

432. *The Standard Unit in the Thermochemistry of Organic Compounds.* **W. Swientoslawski.** (Am. Chem. Soc., J. 39. pp. 2595–2600, Dec., 1917.)—In 1908 Emil Fischer and Wrede expressed the heats of combustion of benzoic acid and of cane-sugar in kilojoules, in accordance with the calorimetric measurements of Jaeger and v. Steinwehr. The author and Popvo then redetermined the heat capacity of the Peters' bomb of the Thermal Laboratory at Moscow, and found values smaller by about 0·5 % than those of Fischer and Wrede. The discrepancy was discussed in Berlin by the author and the others in June, 1914, but not as to the question whether the values should be expressed in kilojoules, about which there is some international uncertainty, or in calories. Cane-sugar is less suitable than benzoic acid, because it is hygroscopic, has a low heat of combustion, and is difficult to ignite when dry. Meanwhile H. C. Dickinson (Bureau of Standards, Sci. Papers, No. 230) published values agreeing as to benzoic acid exactly with Wrede (6323 cals.), whilst the author's value is 6311 cals.; but Dickinson agrees with the author as to the heat capacity of the Peters' bomb, determined by different methods. The author makes definite proposals, to be submitted to the next International Congress, as to the selection of a standard substance and a standard bomb method. Meanwhile he suggests for acceptance the following values for the heat of combustion of 1 gm. (weighed in air) in cals. at 15° : Naphthalene 9612, benzoic acid 6311, cane-sugar 3945 cals. H. B.

433. *Equivalent Conductance of Electrolytes in Dilute Aqueous Solution. I. The Water Correction. II. The Extrapolation of Conductivity Data to Zero Concentration. III. A Study of Dilute Solutions of Potassium Chloride* (by **H. J. Weiland**). IV. *Two Laws Governing the Ionisation Equilibrium Electrolytes in Dilute Solutions, and a New Rule, by means of which the Equivalent Conductance at Infinite Dilution can be determined from a Single Conductance Measurement.* **E. W. Washburn.** (Am. Chem. Soc., J. 40. pp. 106–158, Jan., 1918.)—I. In the first of this series of papers, the author discusses the question of the "water correction" applied to the conductance of very dilute salt solutions, and points out that this "water correction" may amount to 10% of the conductivity of the salt at a concentration of 0·0001 N. and to as much as 1000 % of the conductivity at 0·000001 N. Apart from the magnitude of the correction, doubt also exists as to the proper method of applying it, owing to lack of knowledge of the exact nature and amounts of the impurities present in the conductivity water. Moreover, the conductivity of water exposed to the atmosphere by no means remains constant. After discussing an improved method of "correcting" the conductivity of dilute solutions of salts of strong acids and bases, the author concludes that "the only possible method of securing really dependable Λ_0 values in the case of salts of weak acids or bases (and consequently for determining the anion conductances of these weak acids and bases) is to employ "ultra-pure conductivity water" in making the measurements at high dilutions. In sum, the author does not approve of the use of "equilibrium water" (water in contact with the air) for obtaining true specific conductances at high dilutions.

II. In the second paper of the series, the author adversely criticises the methods hitherto employed by Kohlrausch, A. A. Noyes, Kraus, and Bates, of finding the conductivity at zero concentration. These methods have been carried out by fitting some empirical function to the observed values over at least the lowest portion of the concentration range open to measurement, and then employing this function (expressed either graphically or in the form of an equation) for determining Λ_0. A comparison of the values obtained from the different functions employed, as well as a comparison of the arguments advanced by the authors of these functions in support of the values deduced by them, brings out in a rather striking manner the general untrustworthiness of most of the methods heretofore employed. The author therefore introduces a new graphical method of extrapolation, which consists in plotting values of K_E, the mass-action expression, against corresponding values of the concentration, employing different assumed values of Λ_0 and rejecting those values which cause the curve in dilute solutions to exhibit radical changes in direction. By employing this method it is possible to determine the value of Λ_0 with a precision of 0·01 %, provided the conductance data are as accurate as this, and extend at least to as low a concentration as 0·00002 N.

III. In the third paper, H. J. Weiland describes a method of preparing "ultra-pure conductivity water" by distilling water from a quartz still, and at the same time passing a stream of carefully purified air through the water. In this way water having a conductivity of 0·05 to $0{\cdot}07 \times 10^{-6}$ reciprocal ohms, could readily be obtained. Such water can be kept in a quartz cell practically unchanged as long as 12 hours, provided a stream of purified air is kept slowly bubbling through it. Using this water, the author has determined the conductivity of solutions of potassium chloride ranging in concentration from 0·00002 N to 0·001 N. Adsorption of salt on the walls of the cell was determined and allowed for. The values of Λ_c at round concentrations are given in the following table, the temperature being 18·00°. The mol-weight of potassium chloride was taken as 74·560 :—

Concentration. (Millimoles per Litre.)	True Specific Conductance. $L \times 10^6$ (± 0·02 %).	Equivalent Conductance. Λ_c (± 00·2 %).	$\alpha = \frac{\Lambda_c}{\Lambda_0}$.	$1 - \alpha$.	$K^E = \frac{\alpha^2 C}{1 - \alpha}$.
0·00	0·0	129·64	1·0	0·0	0·020 ± 0·001
0·01	1·2957$_3$	129·57$_3$	0·999$_{48}$	0·000$_{52}$	0·020$_{00}$
0·02	2·5902$_2$	129·51$_1$	0·999$_{01}$	0·000$_{99}$	0·020$_{02}$
0·03	3·8833$_8$	129·44$_6$	0·998$_{50}$	0·001$_{50}$	0·020$_{03}$
0·04	5·1753$_6$	129·38$_4$	0·998$_{01}$	0·001$_{99}$	0·020$_{06}$
0·05	6·4660$_0$	129·32$_0$	0·997$_{53}$	0·002$_{47}$	0·020$_{14}$
0·06	7·7554$_9$	129·25$_8$	0·997$_{05}$	0·002$_{95}$	0·020$_{22}$
0·07	9·0437$_9$	129·19$_7$	0·996$_{58}$	0·003$_{42}$	0·020$_{35}$
0·08	10·330$_9$	129·13$_8$	0·996$_{13}$	0·003$_{87}$	0·020$_{50}$
0·09	11·617$_3$	129·08$_1$	0·9566$_8$	0·0043$_2$	0·020$_{70}$
0·10	12·902$_9$	129·02$_9$	0·9952$_0$	0·0047$_1$	0·0210$_9$
0·20	25·735$_6$	128·67$_8$	0·9925$_6$	0·0074$_4$	0·0265$_0$
0·30	38·535$_3$	128·45$_1$	0·9908$_3$	0·0091$_7$	0·0321$_0$
0·40	51·297$_6$	128·24$_4$	0·9892$_3$	0·0107$_7$	0·0368$_3$
0·50	64·024$_0$	128·04$_8$	0·9877$_2$	0·0122$_8$	0·0397$_2$
0·60	76·721$_4$	127·86$_9$	0·9863$_4$	0·0136$_6$	0·0427$_8$
0·70	89·397$_0$	127·71$_0$	0·9851$_1$	0·0148$_9$	0·0456$_3$
0·80	102·04$_1$	127·55$_1$	0·9838$_9$	0·0161$_1$	0·0480$_6$
0·90	114·66$_0$	127·40$_0$	0·9827$_2$	0·0172$_7$	0·0503$_4$
1·00	127·25$_8$	127·25$_8$	0·9816$_3$	0·0183$_7$	0·0524$_4$

The value of Λ_0 was found to be 129·64 as an average of four determinations. The mass action "constant," K_E, was found to approach a constant value as the solution becomes sufficiently dilute. The limiting value at zero concentration was found to be 0·020 ± 0·001. The empirical equations of Bates and of Kraus, employed to express the relation between equivalent conductance and concentration, have been tested between the concentrations zero and 0·0001 N, and have been found not to be capable of expressing the conductivity data throughout this range.

IV. In the last paper of the series, the author states the following two laws: (1) In sufficiently dilute solutions (*i.e.* for most practical purposes below $C = 0{\cdot}0001$ N) all uni-univalent salts of strong acids and bases obey the mass-action law, and all of them have the same ionisation constant. (2) In sufficiently dilute solution the values of the mass-action expression (and hence also the degrees of ionisation) for all such salts are identical, the identity in the case of any two salts persisting up to higher concentrations, the more nearly the salts under comparison resemble each other, and in any case persisting, within the experimental error of the data now available, up to $C = 0{\cdot}0002$ N for all salts which have been carefully measured below this concentration. In the case of two salts such as potassium chloride and bromide, which resemble each other very closely, this identity persists up as high as 0·005 N. The author also deduces a general rule for determining the Λ_0 values from a single conductance experiment at $C = 0{\cdot}0001$ N, namely, the Λ_0 value for every uni-univalent salt of a strong acid and base at 18°, is 1·00475 times the value of the equivalent conductance at 0·0001 N concentration. This is a deduction from the general relationship

$\Lambda_0 = \Lambda_c(1 + C/K_E)$. By means of this equation the author has calculated the following values of Λ_0: NaCl, 108·57; LiCl, 98·42; RbCl, 133·9; $NaNO_3$, 104·95; KNO_3, 126·02; $LiNO_3$, 94·78; CoCl, 132·90; KBr, 131·71; KI, 130·65; KSCN, 120·8; KIO_3, 98·12; $AgNO_3$, 115·6; $KClO_3$, 119·25; $KBrO_3$, 112·0 ± 0·1; $NaIO_3$, 77·05; $LiIO_3$, 66·92. A table is also given illustrating Kohlrausch's law of the independent migration of ions, and the following ionic conductances at 18° have been calculated: K, 64·30; Na, 43·23; Li, 33·07; Rb, 67·6; Cs, 67·56; Ag, 53·9; Cl, 65·34; NO_3, 61·71; IO_3, 33·83; Br, 67·41; I, 66·35; SCN, 56·5; ClO_3, 54·95; BrO_3, 47·7. A. F.

434. *Electrical Conductance of Solutions in Bromine.* **E. H. Darby.** (Am. Chem. Soc., J. 40. pp. 347–356, Feb., 1918.)—Using the Kohlrausch method, the author has determined the conductance of solutions of triethylammonium chloride in bromine at 18°. These conductance values are found to be greater than those of any of the compounds studied by Plotnikov (*e.g.* iodine bromide and phosphorus pentabromide). The values of the constants m and D in the expression used by Kraus and Bray [Abs. 785 (1914)], $(c\gamma)^2/c(1-\gamma) = D\,(c\gamma)^m + K$, are in fair agreement with those usually found for solutions with different solvents, and the conductance follows the dilution equation of Kraus and Bray. A. F.

435. *Rôle of Ultra-violet Light in Chemical Reaction.* **D. Berthelot.** (J. de Physique, 7. pp. 10–36, Jan.–Feb., 1917. Paper read before the Soc. franç. de Physique.)—In this general article the author gives an excellent account of photochemical action. The real reason for the preponderating importance of ultra-violet light in photochemical action is that although these rays are invisible to our eyes they represent the most intense energetic quality of light. In fact, the frequency of vibration plays, in respect of radiant energy, the rôle of potential (or the intensity factor) which temperature plays in respect of heat energy. We have, therefore, a photochemistry of high vibration frequency, just as we have a thermochemistry of high temperatures, and there is a striking parallelism between the two. In fact the chemical effects of high temperatures can be reproduced by light of sufficiently rapid vibration. Elevation of the frequency cannot only act catalytically but can also displace the equilibrium. For the purpose of measuring the chemical activity of the ultra-violet rays, the author has introduced a new actinometer which depends on the decomposition, with production of carbonic oxide, of ketoses, such as laevulose. By means of this actinometer the gradual deterioration of mercury lamps has been followed. This deterioration has been found to be due to a fine deposit of amorphous carbon on the walls of the lamp, whereby the shorter and more active rays are cut off. By means of ultra-violet light of high frequency endothermic syntheses can be carried out, such as the production of carbohydrates from carbon dioxide and water-vapour. Other syntheses can also be effected by means of the ultra-violet rays of high frequency, and the author has succeeded in synthesising a new compound, $CO(CN)_2$ by this means. Decompositions, similarly, can be effected, and the principal types of fermentation reactions can be carried out. A. F.

436. *The Properties of Mixed Liquids.* III. and IV. *The Law of Mixtures.* I. **J. L. R. Morgan** and **M[ary] A. Griggs.** (Am. Chem. Soc., J. 39. pp. 2261–2275, Nov., 1917.)—(1) From the surface tensions determined by the drop-weight method of 24 homogeneous mixtures in various proportions and at two temperatures, it was found that 10 follow rigidly the law of mixtures

in the form $P_{mix.} = l_a P_a + l_b P_b +$ etc. (where the summation of the relative weights l_a, l_b, etc., is equal to 1 gm.). Of these mixtures, 6 were of two constituents, 2 of three, 1 of four, and 1 of five. (2) Whenever variations appear (the other 14 mixtures) the observed value is invariably less than that calculated from the law. These deviations increase in magnitude with increased temperature, and are always at a maximum at both temperatures for that mixture which contains equal weights (in gm.) of the constituents. (3) Although the deviations might be due to the magnitude of the difference in the surface-tension values of the constituents when pure, the effect is probably negligible and merges into the more important factor—the nature of the constituent. An example of this is chlorobenzene, which renders every mixture of which it forms a part abnormal. The deviation of a complex mixture is not a summation of the deviations of the pairs of liquids of which it could be made, but is of the same order as these. (4) It is shown that chemical interaction for binary mixtures could not be the cause of the max. deviation invariably found at a composition of mixture of 50 % by weight of the two constituents, whereas this behaviour is shown to be exactly that which might be expected if the one liquid by its simple physical presence influenced the value of the property of the other (or if each affected the other), and the conclusion is consequently drawn that the mixture law considered is a rigid law, provided no chemical interaction takes place between the constituents, and neither liquid influences the value of the property of the other. The effect of this latter action is invariably to produce the max. deviation at a 50 % mixture by weight of the two constituents.

The Law of Mixtures. II. **J. L. R. Morgan** and **A. J. Scarlett, Jr.** (Am. Chem. Soc., J. 39. pp. 2275–2293, Nov., 1917.)—The authors have made a complete survey, by the drop-weight method, of the surface tensions of the following ten binary liquid mixtures, in a number of different relative concentrations of constituents, at several temperatures: water-acetone, acetone-ethyl alcohol, phenol-acetone, phenol-ethyl alcohol, benzene-acetic acid, benzene-ethyl alcohol, benzene-methyl alcohol, acetone-methyl alcohol, ethyl alcohol-methyl alcohol, benzene-phenol. The curves representing the variation in surface tension with concentration are in general without maxima or minima, but the benzene-acetic acid mixtures show a minimum, and acetone-ethyl alcohol and acetone-methyl alcohol show maxima. The comparison of the observed results of the various mixtures with the values calculated from the mixture law of Morgan and Griggs (see I.) leads to very interesting and important results here. According to the deviations of the directly observed results from those calculated by this mixture law, the ten systems studied by the authors fall naturally into three groups: (*a*) The systems giving observed values smaller than the calculated one. This is found with water-acetone, phenol-acetone, phenol-ethyl alcohol, benzene-acetic acid, benzene-ethyl alcohol, benzene-methyl alcohol, and benzene-phenol. (*b*) Systems giving observed values larger than those calculated given by acetone-ethyl alcohol and acetone-methyl alcohol. (*c*) Systems which exhibit little or no deviation from the mixture law. Shown by ethyl alcohol-methyl alcohol at 30°. This system is so far unique, for it exhibits a slight positive deviation at 0°, no deviation at 30°, and a small negative deviation at 50°. The position (and magnitude) of the max. deviation from the mixture law found when the deviation is plotted against the concentration of one constituent in gm. per hundred of the mixture divides the systems into two classes. In one class, the max. deviation, always very small, is found for a mixture containing 50 % by weight of each constituent, the composition not being expressible in even molecular weights of the constituents. The only explanation of this is that the behaviour is due to the physical, not chemical, effect of the one liquid on the other. Systems of the other class exhibit a max. deviation, usually large, and at some concentration other than 50 %, and which corresponds always with some simple and even relation of the molecular weights of the constituents, *i.e.* corresponds with a definite chemical formula. The molecular compounds found to exist in liquids by the work of the authors on the basis of the theory of Denison are

$(CH_3)_2CO\ .\ 10H_2O$; $2(C_6H_5OH)\ .\ (CH_3)_2CO$; $C_6H_5OH\ .\ 2(C_2H_5OH)$;
$C_6H_6\ .\ 2(CH_3\ .\ COOH)$; $2(C_6H_6)\ .\ C_2H_5OH$; $C_6H_6\ .\ CH_3OH$;

and $4(C_6H_5OH)\ .\ 3(C_6H_6)$. The compound between benzene and acetic acid to the existence of which the authors' work points, is of interest when considered in the light of the results of other methods which lead to the conclusion that acetic acid is always doubly polymerised in benzene solution; and the evidence pointing to such a compound gives a more advanced point of view on the process which has been designated in the past as a simple polymerisation. A. F.

437. *Depolarisation by Sulphur Dioxide.* **M. de K. Thompson** and **A. P. Sullivan.** (Met. and Chem. Eng. 18. pp. 178–179, Feb. 15, 1918.)—The object of the present investigation was to determine how much the voltage is lowered at the anode of a cell containing sulphuric acid or copper sulphate as electrolyte, when SO_2 is present. The apparatus used consisted of a divided cell, the inner porous pot containing the anode. Sulphur dioxide was passed continuously through the anolyte and the apparatus was kept cool by being placed in a cooling vessel. The potential of the anode was measured by being connected with a hydrogen-sulphuric acid electrode. In making an experiment a constant current was passed through the cell and the anode potential measured over a period of 20–30 minutes, no SO_2 being passed through the anolyte. This was done for a range of current densities varying from 1·25 to 10 amps./dm.^{2}. Then a similar series of runs was made with SO_2 passing through the anolyte, it being assumed that when the potential became constant the solution was saturated and the max. depolarisation had been reached.

Using a smooth Pt anode and 10 % sulphuric acid or 16·5 % copper sulphate as anolyte, there is a reduction in voltage of about 1·5 volts if a certain current density is not exceeded. This current density is between 7·5 and 10 amps./dm.^{2} for sulphuric acid and is less than 7·5 amps./dm.^{2} for copper sulphate. Above these current densities depolarisation did not take place. With an anode of "duriron" the depolarisation is not so great, being of the order of 1·10–1·16 volts. The fact that the extent of the depolarisation depends on the nature of the anode will explain the somewhat different figures obtained by M. R. Thompson (*ibid.* 16. p. 178, 1917) when using an anode of platinum black. T. S. P.

438. *Potential of the Bromine Electrode; Free Energy of Dilution of Hydrogen Bromide; Distribution of Bromine between several Phases.* **G. N. Lewis** and **H. Storch.** (Am. Chem. Soc., J. 39. pp. 2544–2554, Dec., 1917.)—The potential of the bromine electrode has been studied in much detail by Boericke, but unfortunately, as in most of the earlier investigations of electromotive force, the use of concentrated solutions, the lack of information concerning the corrected degree of dissociation, and the introduction of

liquid potentials of uncertain magnitude render it difficult to make accurate calculations from the measurements. Thus Boericke, who used various concentrations of bromine in solutions of potassium bromide between molal and tenth molal, obtained values for the normal electrode potential which varied by 0·008 volt. In this paper the authors attempt to fix the value of the normal electrode potential within a few tenths of a millivolt. Potential measurements in potassium bromide solutions are first described with experimental details, a definite bromine content being obtained by shaking with successive portions of a known solution of bromine in carbon tetrachloride. The results from these preliminary experiments show considerable variation, undoubtedly due in large measure to the liquid potentials which were neglected, and also to a magnification of errors which enter into the determination of the concentration of potassium bromide. Owing to the difficulty of eliminating the hydrolysis of bromine, without at the same time producing liquid potentials of uncertain magnitude, another series of measurements was made using solutions of hydrobromic acid instead of potassium bromide, and the hydrogen electrode instead of the normal calomel electrode. Having found the dissociation constant of the tribromide used to be reliable, no attempt was made to fix the bromide concentration by shaking with carbon tetrachloride solution, which was calculated from the total bromine as determined experimentally. The free energy of dilution of hydrobromic acid is next dealt with, and measurements are described with the cell H_2, HBr, AgBr, Ag using three different concentrations of HBr. The corrected degrees of dissociation are shown to be identical with those of hydrochloric acid. Work was next undertaken on the distribution of bromine between water and carbon tetrachloride, and between aqueous hydrogen bromide and carbon tetrachloride. In order to obtain the potential of gaseous and liquid bromine, when that of molal aqueous bromine is known, the authors have investigated the partial vapour pressure of bromine from solutions in carbon tetrachloride. The method adopted was a dynamical one, consisting in passing a known volume of air through the solution in a series of absorption vessels, and then determining iodometrically the amount of bromine evaporated. The vapour pressure was found to be proportional to the mol fraction in the latter phase. The following normal electrode potentials against hydrogen at 25° are given :—

$$Br_2(aq.),\ Br^- \| H^+,\ H_2\ ;\ E^\circ = -1{\cdot}0872.$$
$$Br_2(l),\ Br^- \| H^+,\ H_2\ ;\ E^\circ = -1{\cdot}0661.$$
$$Br_2(g),\ Br^- \| H^+,H_2\ ;\ E^\circ = -1{\cdot}0824.$$

H. H. Ho.

439. *Comparison of the Activities of Two Typical Electrolytes.* **G. A. Linhart.** (Am. Chem. Soc., J. 39. pp. 2601–2605, Dec., 1917.)—Using the improved hydrogen electrode and calomel electrode previously described [see Abs. 321 (1918)] the author has measured the e.m.f.'s of combinations of the calomel electrode against a hydrogen electrode in solutions of hydrochloric acid varying in concentration from 0·01006 to 16·0 mols. per 1000 gm. of water ; these measurements are then corrected to give the values of the e.m.f. when the hydrogen pressure is 1 atmo. From the results the activity products of $(\mathrm{H}^{\cdot})(\mathrm{Cl}')$ and the equilibrium constant $(\mathrm{H}^{\cdot})(\mathrm{Cl}')/(\mathrm{HCl})$ are calculated ; the values of the thermodynamic degree of dissociation are then compared with those previously obtained for potassium chloride (Linhart, Am. Chem. Soc., J. 39. p. 618, 1917). Contrary to assertions frequently found in the literature, these "thermodynamic" degrees of dissociation of HCl and KCl are not equal even in dilute solution (0·82 and 0·78 respectively in 0·1-N solution), whilst in concentrated solution the divergence is enormous.

In a footnote calculations of the vapour-pressure data for aqueous solutions of hydrochloric acid at 25° are given, the calculations being based on results obtained by Dolezalek for such solutions at 80° (Zeits. phys. Chem. 26. pp. 884, 1898). T. S. P.

440. *Electrochemical Behaviour of Nickel.* **A. Smits** and **C. A. L. de Bruyn.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 894–408, 1918.)—In recent years it has been shown in the Amsterdam Laboratory that one of the most characteristic properties of a metal is the velocity with which it assumes electromotive equilibrium at a definite temperature and pressure. At the ordinary temperature and pressure this velocity is very small for the metal in the dry condition; in contact with an electrolyte, however, the velocity is quite different, although complications are then caused by the appearance of catalytic actions, both positive and negative. These catalytic actions make the comparison of the behaviour of different metals a difficult matter, as has already been shown in the case of iron immersed in different electrolytes.

Some metals, however, assume internal equilibrium very slowly in contact with an electrolyte, and nickel is one of these. With this metal, not only oxygen, but also hydrogen, acts as a negative catalyst, and the catalytic effect is very pronounced. For example, when hydrogen at a pressure of 1 atmo. is led through a solution of nickel sulphate in which Ni electrodes are immersed, the equilibrium is disturbed either in the base or noble direction until the electron concentration of the metal equilibrium becomes equal to that of the hydrogen equilibrium in the electrolyte. It can be shown that in this case the p.d. of the Ni with respect to the electrolyte, not taking into account the Volta-effect, must become equal to the p.d. of the hydrogen electrode: experimentally it was found that practical equality of these two p.d.'s exists.

It is shown by theoretical considerations that the unary equilibrium potential for Ni is only to be expected in an atmosphere free from oxygen or hydrogen, or in a vacuum, and when a solution of a nickel salt is used in which the hydrogen concentration is less than 10^{-8} for a nickel ion concentration of 1. Experiments made in accordance with these theoretical considerations gave —0·480 volt, with respect to the normal calomel electrode, as the equilibrium potential, which value agrees entirely with that calculated by Wilsmore and also with that found by Schoch in an experiment in a vacuum. It is pointed out that in the many potential measurements of Ni which have been carried out in the air or in a hydrogen atmosphere, the equilibrium potential of the unary Ni has not been measured, but rather the potential of a state of this metal which has been disturbed in a base or noble direction. T. S. P.